



Massachusetts Military Reservation

PLUME RESPONSE PROGRAM

DRAFT SD-5 NORTH CONTAINMENT SYSTEM DESIGN REPORT VOLUME 1

November 1996

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SD-5 NORTH PROJECT DESIGN REPORT UPDATE

November 1, 1997

The SD-5 North Draft Design Report was prepared to address the design basis to complete the engineering and design of the extraction, treatment, reinjection (ETR) system for the containment of the SD-5 North (Storm Drain - 5 North) plume. This document was issued for comment 4 November 1996 using the most current information and data available at that time. Comments on the document were received, responded to and resolved with the regulators, TRET and JPAT members and other stakeholders as summarized in Attachment I.

This letter is intended to provide the necessary background to bridge the period between the drafting of the Draft Design Report and the final design used for construction.. It will also serve as the vehicle that will close the document review process and result in the Draft Design Report becoming final.

The process operation of the system remains the same as described in the Draft Design Report with groundwater being extracted from the aquifer to the influent tank, pH adjustment, followed by greensand filtration, granulated carbon filtration and reinjection to the aquifer. The system's average operation rate is 355 gpm as previously reported.

Since the publication of the Draft Design Report in November 1996, several changes have been made to the plume definition and to the extraction and reinjection wellfield as a result of a pre-construction investigation program. Value engineering resulted in some changes to the control philosophy for operations.

The Draft Design Report originally included 18 extraction and 18 reinjection wells in the design. Through additional data collection, modeling, and value engineering the current wellfield configuration was optimized to 10 extraction wells and 8 reinjection wells. The current layout of these wells on the plume is shown in Figure 1, attached. To meet Massachusetts fire regulations the chemical storage tanks, hydrogen peroxide, sodium hydroxide and sodium hypochlorite were moved outside the treatment building. A fire detection system was added that connects with the MMR base wide fire alarm system and to the instrumentation/control system.

Supporting documents that are referred to within the text of the Draft Design Report have been written. These include the Draft Project Execution Plan and Performance Monitoring Plan (PME). The SD-5 Draft Modeling Report has been written and is ready for review.

Upon completion of the as-built drawings, the Piping and Instrument Diagrams(P&IDs) will be forwarded to each holder of the Draft Design Report for their information. The P&IDs will serve as the final design basis for the operating ETR system.

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ATTACHMENT I

Responses to Comments on the Draft Design Report for the SD-5 North Containment System Dated November 1996

Responses to P. Marchessault (USEPA) Comments Dated 22 November 1996

General Comments

1. The SD-5 draft design appears to be reasonable with respect to known aquifer characteristics and the estimated contaminant distribution in the vicinity of the extraction and reinjection fences. Several data gaps have been identified, however, and will need to be resolved prior to installation and startup.

Response: Agreed. Prior to installation of the extraction fence the preconstruction data investigation will be performed to more accurately define the plume boundaries as defined in the Draft Execution Plan.

2. The physical components of the system allow for considerable operational flexibility with respect to extraction and reinjection rates. Once final extraction and reinjection well locations are known, a sensitivity analysis must be performed to verify that operation of extraction and reinjection rates over the design range will not result in unacceptable deflection of either the Western Aquafarm or the PFSA plumes.

Response: Agreed. The Performance Monitoring Evaluation Plan will address system operation.

Page Specific Comments

- **Comment #1, Page 2-12, §2.4.1, ¶1:** Replace Scenario 15 with Scenario 6 in the last sentence.

Response: The text will be modified accordingly.

- **Comment #2, Page 2-40, §2.7, Bullet 5:** Replace CS-120 East with CS-10 East.

Response: The text will be modified accordingly.

- **Comment #3, Page 2-46, Table 2-3:** The Federal MCL for EDB is 0.05 ug/l and the State MCL for EDB is 0.02 ug/l. Please revise accordingly. If drinking water guidance values are available for constituents identified as "Listed for promulgation" indicate the guidance value and footnote the source.

Response: The table will be modified to reflect that the Massachusetts MCL for EDB is 0.02 µg/l.

- **Comment #4, Page 2-49, §2.8.3:** It is important that the hydraulic monitoring system be capable of providing data which can be used to adjust pumping rates following startup and demonstrate effective operation. This should not be considered a design limitation.

Response: Hydraulic monitoring will be part of the system monitoring. However, it must be recognized that in order to ensure that the SD-5 extraction system has minimal hydraulic impact, the magnitude of measurable drawdown during system operation will be limited. Specific details



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concerning performance monitoring will be provided in the Performance Monitoring Plan, which will be submitted under separate cover.

- **Comment #5, Page 3-6, §3.1.5, ¶3:** Advantages and disadvantages associated with the addition of hydrogen peroxide and/or sodium hypochlorite must be evaluated in order to determine whether or not a pro-active or reactive program will be adopted as an operational strategy for biocide addition. The monitoring program should include sampling for residuals, if necessary.

Response: Facilities have been provided to allow the addition of hypochlorite to the water leaving the treatment system, if needed to control generalized biological fouling. Chlorine is not stable in the environment, it reacts with any organic material present and converts to the chloride. So, the chlorine should not migrate any significant distance from the reinjection wells. However, a literature search did not reveal any definitive information on the migration of free chlorine, so the addition of hypochlorite will be used with caution.

The projected continuous dosage is specified as 2 mg/l free chlorine. This dosage will be used if an increase in pressure drop at the reinjection wells indicates that biological fouling is occurring in all the wells. "Shock" loading if required will be conducted using standard procedures for disinfecting water wells. Shock loading would be conducted at individual wells as part of any required redevelopment of the wells, and would only be conducted if severe fouling occurs at any of the wells. The shock loading would be accompanied by jetting, or some other physical form of forcing the chlorine into the formation, and may also be accompanied by acid washing to dissolve any precipitated inorganics. If continuous injection is used, hypochlorite will be added to the water leaving the treatment system. If shock loading is required, it will be performed at the individual wells.

A literature search did not reveal any experience with the continuous use of chlorine to control fouling in reinjection wells. The 2 mg/l dosage rate was based on standard guidelines for disinfecting potable water and wastewater, plus was based on conversations with Betz, a major supplier of hypochlorite. Shock loading is a common approach to controlling the bacteria growth in water wells. "Groundwater Technology", by Fletcher G. Driscoll provides information on standard shock loading procedures, using free chlorine concentrations in the 500 mg/l to 2000 mg/l range. The book provides examples of satisfactory performance using this shock loading combined with other activities such as "jetting" to agitate the formation, and acid washing to remove any inorganics precipitated by the bacteria.

Plugging of the reinjection wells will be monitored by the level in the wells and by the wellhead pressure. The first indication of plugging will be a rise in the level in the wells. The second indication will be an increase in pressure - the system is designed to provide up to 25 psig pressure, at the wells, to help force the water into the formation. Increases in level and/or pressure will be plotted to provide information on when the plugging will begin to impact capacity.

If hypochlorite is added on a continuous basis, downstream monitoring wells will be sampled to insure that free chlorine is not migrating from the site. After shock loading, the chlorinated water can be removed from the wells, following the standard procedures for chlorinating wells, so long term monitoring would not be required.

- **Comment #6, Page 3-8, §3.2.1, ¶1:** Please correct the concentration unit included in the text.

Response: The concentration will be corrected to µg/liter.

- **Comment #7, Page 3-18, §3.2.2, ¶1:** Replace FS-12 with SD-5.

Response: The text will be modified accordingly.

- **Comment #8, Page 3-27, §3.3, Bullet 2:** Has it been determined that activated carbon, preceded by a UV/peroxide system, is economically feasible at SD-5? Please clarify.

Response: Wells sampled during the fall, 1996, Western Aquafarm quarterly sampling program and SD-5 North data gap program resulted in EDB being detected in only one well, MW-574. Based upon the sampling results, a UV/peroxide system is not economically feasible at the SD-5 North ETR. Reference to the UV/peroxide system will be deleted.

- **Comment #9, Page 4-2, §4.1.1, ¶1:** Correct the units listed in the last sentence (i.e., change 23,000 gpm to 23,000 gallons).

Response: The text will be modified accordingly.

- **Comment #10, Page 6-1, §6.1, Bullet 1:** Delete the phrase "located north of Snake Pond".

Response: The text will be modified to read "located north of Ashumet Pond".

- **Comment #11, Appendix B:** Please indicate the basis for projecting iron and manganese concentrations. The tables do not appear to contain metals data.

Response: Historical data were used to project the iron and manganese concentrations referenced in Appendix B. Updated data have been received during the Inorganics Investigation. The table in Appendix B will be updated to reflect the current information.

General Comments

1. Design Effectiveness:

The final SD-5 extraction-treatment-and reinjection ("ETR") system should be designed to capture 100% of the SD-5 North plume while not dispersing either the southern portion of the SD-5 Plume or any adjacent plumes. The model for the current design does not show capture of 100% of the plume, nor has AFCEE demonstrated that adjacent plumes will not be impacted. Please indicate the model with the most recent field data collected. Please conduct subsequent runs of the updated model to develop a final design that will capture 100% of the plume, without inducing plume dispersal of either the southern portion of the SD-5 plume or any adjacent plumes.

Response: AFCEE is currently performing a variety of data gap activities that will be used to refine the boundaries of the SD-5 plume and the design basis of the SD-5 ETR system. Following data gap collection activities, additional particle tracking runs will be presented to all stakeholders for review and approval. These modeling runs will include an evaluation of the impact of the SD-5 ETR system on other plumes. The extraction fence will be located to capture the SD-5 North plume. The extraction fence is not being designed to capture contaminants from other areas such as Western Aquafarm.

2. Data Summary and Evaluation:

Please provide particle track analyses and areal and vertical flow net analyses. In addition, please demonstrate plume capture, downgradient and side gradient aquifer impacts, and the efficacy of the currently proposed vertical offset between the elevations of the extraction well screens and the reinjection well screens.

Response: AFCEE is currently performing a variety of data gap activities that will be used to refine the boundaries of the SD-5 plume and the design basis of the SD-5 ETR system. Following data gap collection activities, additional particle tracking runs will be presented to all stakeholders for review and approval. Final particle track analyses and areal and vertical flow nets showing the extent of plume capture will be presented under separate cover for review and approval at that time.

3. Performance Monitoring System

On page 4-8 of the September, 1996 "Draft SD-5 Execution Plan" (the "Plan"), under the heading 4.3.3 Monitoring Well Installation, AFCEE indicates that "Procedures and construction details for installation of the piezometers and monitoring wells will be described in the Draft Design Package" (the Report). However, AFCEE has not included this information in the Report. Please include.

Response: Monitoring well installation. SOP, is available in the Jacobs QPP for the MMR Program.

4. Model Representativeness

In the Report, the amount of data collection proposed to define the stratigraphy of the aquifer has been scaled back from the amount of data collection proposed in the Plan. The Department is concerned that the reduction of the quantity of data being collected to support the design of the ETR fence will compromise final design and potentially impair performance evaluation. Specifically, the Department objects to the omission of borings to characterize site lithology, the omission of gamma and resistivity logging, the reliance on SHSA borings to estimate rather than confirm site stratigraphy, and the

omission of an adequate number of appropriately placed observation wells to use in the 72 hour pump test. Please clarify how the changes proposed in the Report will improve the model of the SD-5 Plume and the design of the ETR system.

Response: A total of four pilot borings will be conducted at locations across the ETR fence area, using the Rotasonic drilling method. In the Execution Plan, it was proposed that pilot borings would be conducted using hollow stem auger method (split spoon or split barrel sampler) and geophysical analysis using gamma ray and resistivity logging. In the Design Report, this method was replaced with rotasonic drilling method, which permits continuous core sampling, resulting in continuous lithologic identification and strategic correlation.

A total of eight new observation wells and four existing monitoring wells were continuously monitored with a data logger during the pumping test. It is the position of Jacobs that an adequate number of wells were used during the pumping test to effectively obtain hydraulic parameters.

Page Specific Comments

- **Comment #1, Page 2-22, Section 2.5.2:** The Department recommends the baseline sampling plan be expanded. The following wells should be added to the Baseline Sampling Program:

MW-6, MW-6 A
MW-11
MW-12
MW-13
MW-15
MW-18 B
MW-20 A, B

Response: As discussed in Section 2.5.2, a more comprehensive round of groundwater sampling will take place prior to system startup. The details of this comprehensive "baseline" groundwater sampling round will be provided in the performance monitoring plan, which will be submitted under separate cover.

- **Comment #2, Page 2-23, Section 2.5.4, paragraph 1:** Please provide, as expeditiously as possible, the SD-5 North Pumping and ReInjection Test Workplan that was due in early November.

Response: The Workplan for the SD-5 North Plume Injection Program will be distributed for general information in late January 1997. This Plan will be similar to the plan approved by the regulators prepared by Optech for FS-12 Pump/Reinjection test.

- **Comment #3, Page 34, Paragraph 2:** While AFCEE is expected to meet state permit requirements as performance standards for the discharge of treated groundwater to the ground, a permit is not required.

Response: We agree that a permit is not required but the discharge from the treatment facility must meet the Commonwealth discharge requirements.

- **Comment #4, Page 2-43, Section 2.7.2, paragraph 1:** Although EPA Method 502.1 provides gas chromatograph/mass spectrometer ("GC/MSS") confirmation of EDB, this method is somewhat less sensitive than EPA Method 504. The Method Detection Limit ("MDL") for EPA Method 504 is 0.010 ppb while the corresponding MDL for EPA Method 502.1 is 0.400 ppb. Therefore, the Department does not recommend the use of EPA Method 502 as an alternative to EPA Method 504.

Response: EPA Method 502 will not be used as an alternative to EPA Method 504. The text will be modified accordingly.

• Comment #5, Page 2-46, Table 2-3:

- a. Please provide specific analytical reference (i.e. 502.1, 502.2 or 524.2) for each Contaminant of Concern (COC).
- b. The concept of a Practical Quantification Limit (PQL) is usually associated with wastewater analysis. Method Detection Limits (MDLs) for various analyses are experimentally determined using various analytical standards prepared with reagent grade water and do not account for the matrix effects routinely encountered in wastewater analysis. For standard drinking water analysis PQLs and MDLs are in most cases the same value because of the absence of matrix effects. If a matrix effect is suspected, a PQL can be determined experimentally utilizing standard addition techniques. Please replace estimated PQLs with MDLs.
- c. The MDL for EDB using EPA Methods 504 is 0.010 ug/l (ppb). Therefore, the cleanup level for EDB should be below 0.010 ug/l.
- d. Cleanup Levels for all organic contaminants in groundwater should be non-detect ("ND").
- e. Contract Required Quantification Limits ("CRQL") for USEPA contract laboratories have no relevance for the analysis of groundwater to determine compliance with drinking water standards. Please remove the CRQL column.
- f. Please indicate that the MCLs reflect the more stringent of the Federal or Massachusetts MCLs (MMCLs). For example: the MMCL for EDB is 0.02 ug/l (micrograms per liter), which is more stringent than the Federal MCL of 0.05 ug/l.
- g. The Cleanup Level for Iron should be changed to 0.07 ug/l.
- h. Please include methyl tertiary butyl ether ("MTBE") in Table 2-3 as a Contaminant of Concern ("CoC"). The MMCL for MTBE is 70 ppb.

Response:

- a. The text will be modified to provide specific analytical reference.
- b. The text will be provided as appropriate.
- c. The design basis for the treatment of EDB in the extracted groundwater is treatment to non-detect.
- d. The design basis for treatment of all the organic compounds listed in Table 2-5 is treatment to non-detect. However, in other plumes at the site, organic compounds may be present that are non-toxic (high MCLs or no MCLs) and that are not readily amenable to treatment. If non-toxic organic compounds are detected during the evaluation of the other plumes at the facility, treatment levels for those compounds will be determined on a case by case basis.
- e. The MCL for EDB will be revised, and footnoted, to reflect the lower Massachusetts MCL of 0.02 microgram/l.
- f. The text will be modified as appropriate.
- g. Treatment to an iron concentration of 0.07 µg/l is not feasible using the proposed treatment system. Discussions with the vendors of the Greensand filters indicate that it should be possible to remove 90% of the iron, which is the basis for our design basis treatment concentration of 53 µg/l.

however there is no requirement for the removal of iron other than the need to reduce the iron concentration as a pretreatment step upstream of the carbon filters. Iron and manganese are both naturally occurring in the groundwater in the region so the only discharge requirement should be the requirements of 314 CMR 5.00 (Groundwater Discharge Permit Program) which list the maximum allowable iron concentration of 300 µg/l and the maximum manganese concentration of 50 µg/l. The cleanup levels for iron and manganese listed in Table 2-5 are typographical errors. The correct cleanup levels for these two compounds should be listed as 300 µg/l and 50 µg/l respectively.

h. The table will be modified accordingly.

- **Comment #6, Page 2-43, Section 2.7.2:** Please modify the text in this section to reflect the changes to Table 2-3 that are listed in the preceding Page Specific Comment No. 5., items a through h.

Response: The text will be modified accordingly.

- **Comment #7, Page 3-2, Section 3.1.2, last paragraph:** Please provide a proposed Greensand Filter System pH control range.

Response: The Greensand Filter System requires a minimum pH of 6.0. A control system will maintain a pH between 6.5 and 8.5.

- **Comment #8, Page 3-13, paragraph 1:** Septic systems operated by the Federal Government are exempt from construction permits from local board of health. State permits are required, however.

Response: A state permit will be obtained from the Massachusetts DEP.

- **Comment #9, Page 3-35, Section 3.3.2, last paragraph:** The design basis for permanganate addition should also include other readily oxidizable substances present in groundwater (i.e. soluble organic carbon, sulfides, etc.).

Response 9: The potassium permanganate will be added in sufficient quantities to oxidize the iron and manganese present. If compounds are present that also react with the permanganate, the addition rate will be increased accordingly.

Responses to J. Dickerman and C. Runk (HAZWRAP) Comments dated November 20, 1996

- **Comment #1, Page 1-8, Sect.1-2, 3rd bullet, second sentence:** Add total dissolved solids to the list and change "nutrient" to micronutrient".

Response: The text will be modified accordingly.

- **Comment #2, Page 2-4, Sect 2.1, second paragraph, second sentence:** Change sentence from "...70 feet below the water table (-20 msl)..." to "...70 feet below the water table surface (-20 msl)..."

Response: The text will be modified accordingly.

- **Comment #3, Page 2-24, Sect.2.5.5, second paragraph:** The ecological resources nearest to the SD-5N ETR include, as mentioned, the two bogs. Ashumet Pond and the vernal pool were included in the earlier Field Sampling Plan. Will the two bogs be added to the sites to be characterized and monitored? And if so, when is sampling to begin and what document will discuss this?

Response: Ecological sampling associated with the SD-5 containment system will be planned and conducted as specified in the Draft Work Plan for the Ecological Assessment Associated with Groundwater Plumes and Remedial Activities at MMR (January 27,1997). The ecosystems which will be selected for sampling and specific sampling and analysis associated with SD-5 will be presented in the Plume-specific Ecological Sampling Plan. Pre-draft Sampling Plan tables and figures will be provided for review and a pre-draft meeting is scheduled for February 4, 1997. The pre-draft meeting will be used to discuss rationale and sample design for ecosystems related to the SD-5 treatment system.

- **Comment #4, Page 3-6, Sect. 3.1.5, third paragraph in Sect. 3.1.5, second sentence:** Would like more details included in text on the dosage, and likely sphere of impact when shocking or continuously feeding the NaOCl biocide.

Response: The current design provides piping connections that will allow the continuous addition of up to 2 mg/l free chlorine, if required, to control generalized fouling in the wells. Chlorine is not stable in the environment, it tends to react with any organic material present such as bacteria or soil humus. So, the chlorine should not exist very far from the well. A literature search was conducted to determine if information was available on how far the chlorine could migrate. No useful information was found so the current design basis is to add hypochlorite only if a plugging problem occurs that requires control. If the hypochlorite is added, samples will be collected from downgradient monitoring wells to insure that free chlorine is not migrating from the site.

If individual wells lose capacity because of biological plugging, those individual wells can be given "shock loadings" of hypochlorite. Shock loading uses free chlorine concentrations as high as 500 mg/l to 2000 mg/l, frequently combined with re-development of the well and acid washing. If "shock loading" is required it will be performed at individual wells, using standard procedures for disinfecting water wells.

- **Comment #5, Page 3-25, Sect. 3.2.2, last paragraph:** Please update this information here AND where ever else test is appropriate as to the pH requirements from the state with regards to the effluent requirements. It was understood that the state granted a variance that allowed for the pH of the reinjected groundwater to be reinjected at the ambient groundwater pH. If this is the intention, please specify. Adjusting the pH of the treated effluent water to the ambient pH will remove any ecological concerns associated with the changes in pH of the groundwater.

Response: The pH of the reinjected water will either be the same as ambient, or it will be in the range 7.0 to 8.5 required by the reinjection regulations. If possible, the pH will not be adjusted in the treatment system, however pH adjustment to between 7.0 and 8.5 may be required for iron and manganese removal.

- **Comment #6, Page 6.1, Section 6.1, first paragraph, first bullet:** Change first bullet from "...remediation of the SD-5 plume located north of Snake Pond." to "...remediation of SD-5 plume located north of Ashumet Pond."

Response: The text will be modified accordingly.

General Comments

1. Clarity and Organization

The draft specifications and drawings are generally clear and well organized, with exceptions described under Technical Issues, below.

The Draft Design Report, including appendices, is generally clear and well organized, but does not clearly present the basis of the groundwater remediation system design, as described under Completeness and Technical Issues, below.

2. Completeness

The Draft Design Report is unclear regarding selection and sizing of the proposed remediation system. Some of the included data seem to suggest that the system may be undersized. WPI recommends that the Draft Design Report be revised to clearly explain system selection and capacities and that supporting calculations be provided.

The Draft Design Report contains no estimate of the time required to remediate the plume; therefore, long term project costs cannot be estimated. WPI recommends that the time for plume remediation be estimated and that supporting calculations be provided.

The Draft Design Report presents insufficient information to demonstrate that the proposed carbon adsorption treatment system is the most appropriate and cost effective alternative for the SD-5 plume remediation. WPI recommends the report be revised to more thoroughly describe the alternative evaluation process, including the application of qualitative information in formulating the acceptance/rejection decisions.

Response:

Supporting calculations will be provided in the appendix to the Draft Design Report.

Since no contaminant transport modeling has been performed the time for plume remediation cannot be estimated with sufficient level of accuracy at this time.

A detailed evaluation of alternates was performed for the FS-12 design, this report is available. The FS-12 evaluation verified that the treatment systems as designed for both FS-12 and SD-5 will successfully treat the extracted water for the range of expected inlet flows and concentrations. The evaluation did determine that more economical options potentially exist, but because of the tight schedule the decision was made to retain the OPTEC design basis to insure that the project schedule could be met. The inlet concentrations to the SD-5 treatment system are considerably lower than the concentrations expected at FS-12, which means that the carbon consumption at SD-5 will be very low. Because the operating cost for SD-5 will be low, no alternates evaluation study was conducted for SD-5.

3. Technical Issues

Engineering

- **Specifications** - The Draft Specifications are unclear and inconsistent in use of the terms "work" and "project," and regarding when acceptance or close-out occurs. Certain sections (e.g., 01010) indicate operation and maintenance services are to be provided for a period of twelve (12) months following acceptance, whereas other sections (e.g., 01700) indicate the project shall be determined complete when all equipment and materials are installed. WPI recommends the project, scope of work, and related specification terms be clearly defined.

Influent contaminant concentrations shown in the specifications (system data sheets - Division 11) are not the same as the contaminant concentrations shown on the mass balance table of the Process Flow Diagram (Drawing SD-5-1106-002). Although the Draft Design Report states that different contaminant concentrations were utilized for system unit capacity determinations and for process flow mass balance, this is not explained in the specifications. WPI recommends the specifications/drawings be revised to clearly indicate the purpose of the information in the process Flow Diagram Drawing mass balance table and that system capacity is based on information in the system data sheets in Division 11.

The Draft Specifications also lack a design life for many treatment system components. WPI recommends the project life be estimated and treatment system component design lives be specified.

- **System Design Methodology** - The Draft Design Report does not clearly describe the treatment system design methodology and capacity determination. The treatment system capacities are reportedly based on plume contaminant concentrations described in the report as average and "hot spot" concentrations, calculated as shown in Appendix B. These calculations and the subsequent application of the data to the design process are unclear. The "hot spot" concentrations calculated in Appendix B and those shown in the body of the report (page 2-42) are not the same, and the concentrations presented in the specifications are different from both of these. The concentrations presented in the specifications appear to be from an earlier study and preliminary design termed the OpTech 60% design (OpTech, 1996). Also, information in Appendix C describing pilot studies conducted by Calgon Carbon Corporation for the SD-5 plume does not include data on study influent contaminant concentrations other than methylene chloride at 0.35 ppb.

Another factor potentially impacting appropriate influent contaminant concentrations is the definition of the plume to be treated. It is noted that the subject draft design references an SD-5 North plume coinciding with the remainder of the SD-5 plume and two other plumes (Western Aquafarm and PFSA), and that further data acquisition and plume definition are forthcoming.

WPI recommends that the Draft Design Report be revised to clearly explain the treatment system design methodology, including a table of design influent concentrations and a step-by-step description, with calculations and graphic solutions, of the determination system unit capacities and major operational aspects such as activated consumption rates.

Response:

The operating responsibilities are currently being defined.

The concentrations in the specifications do not match the concentrations on the PFD and in the Design Report because the specifications were prepared before updated concentrations were determined. The concentrations listed in the specifications were obtained from the OPTEC 60% design. After updated concentrations were determined, the decision was made not to change the concentrations in the



specifications. The specifications were not changed to avoid any slowdown in the procurement process. The equipment has already been purchased so there is no basis to revise the specifications.

Value engineering studies were all based on an assumed project life of 25 years.

The "hot spot" concentrations listed in Appendix B are identical to the concentrations used as the equipment sizing basis on page 2-42 of the Design Report, only the Design Report includes a few additional compounds.

Appendix C does not discuss any Calgon pilot studies conducted on the SD-5 plume, no pilot studies were conducted on SD-5, only on FS-12. Appendix C does contain a large amount of data on laboratory, pilot, and full scale tests conducted on groundwaters containing all the critical contaminants in the SD-5 plume.

The concentrations listed in the Design Report include the influences of the Western Aquafarm PFSA plumes.

Page Specific Comments

- **Comment #1, Page iii, Line 21** states that Figure 3-4 is labeled "Groundwater General Response Action;" however, Figure 3-4 is labeled "Process Treatment Facility Screening Process." WPI recommends this difference be reconciled.

Response: The text will be modified to state that Figure 3.4 is labeled "Process Treatment Facility Screening Process".

- **Comment #2, Page iii, Line 22** states that Figure 3-5 is labeled "Groundwater Detailed Response Action;" however, Figure 3-5 is labeled "Process Treatment Facility Screening Process." WPI recommends this difference be reconciled.

Response: The text will be modified to state that Figure 3.5 is labeled "Process Treatment Facility Screening Process".

- **Comment #3, Page iii, Line 26** states that Table 2-3 is labeled "Cleanup Levels - Groundwater;" Table 2-3 is labeled "Cleanup Levels - Treated Effluent."

Response: The text will be modified to state that Table 2-3 is labeled "Cleanup Levels - Treated Effluent".

- **Comment #4, Page 1-5, Figure 1-2, Figure 1-2** shows the entire SD-5 plume; however, the Draft Design Report addresses only SD-5 North. WPI recommends that the segments of the SD-5 plume be delineated.

Response: The SD-5 North plume will be delineated.

- **Comment #5, Page 1-5, Figure 1-2:** Many important features are not labeled or are unclearly labeled on Figure 1-2. WPI recommends that all pertinent features be labeled clearly.

Response: The figure will be modified so that all pertinent figures are clearly labeled.

- **Comment #6, Page 2-3, §2.1, Section 2.1** states that part of the plume has migrated off site; however, it is unclear whether this refers to the SD-5 plume or the SD-5 North plume. WPI recommends this be clarified.

Response: The portion of the SD-5 plume that has migrated off-site will be clarified.

- **Comment #7, Page 2-3, Figure 2-1:** See comment 5.

Response: See response 5.

- **Comment #8, Page 8, 2-5, Figure 2-1:** The legend indicates Cross Section A-A' is on Figure 2-2; A-A' is located on Figure 2-3. WPI recommends the legend be corrected.

Response: The legend on Figure 2-3 will be modified to indicate that Cross Section A-A' is located on Figure 2-3.

- **Comment #9, Page 2-5, Figure 2-1:** The legend indicates Cross Section B-B' is on Figure 2-3; B-B' is located neither on Figure 2-1 nor Figure 2-3. WPI recommends the reference to B-B' be removed from the legend of Figure 2-1.

Response: The reference to B-B' will be removed from Figure 2-3.

- **Comment #10, Page 2-5, Figure 2-1:** Groundwater screening locations 1-5 referred to on pages 2-19 and 2-20 are not shown on Figure 2-1. WPI recommends that the locations of these screening locations be added to Figure 2-1.

Response: The groundwater screening locations will be added to Figure 2-1.

- **Comment #11, Page 2-7, Figure 2-2:** See Comment 5.

Response: See Response 5.

- **Comment #12, Page 2-7, Figure 2-2:** Figure 2-2 is labeled "SD-5 North Plan Map of the Various Plumes;" however, only the Western Aquafarm plume boundary is shown. WPI recommends that the boundaries of all plumes referred to be delineated on Figure 2-2.

Response: The boundaries of all pertinent plumes will be delineated.

- **Comment #13, Page 2-8, § 2.1:** The abbreviation PFSA is not defined. WPI recommends that all abbreviations be defined when first used and that they be included in the list of acronyms and abbreviations.

Response: The Petroleum Fuel Storage Area plume (PFSA) will be defined and will be included in the list of acronyms and abbreviations.

- **Comment #14, Page 2-10, §2.4.1:** The last line on page 2-10 cites Therrien, R. Et al, 1994. This reference is not included in the references in Section 7.0. WPI recommends that Therrien et al., 1994, be added to Section 7.0.

Response: The reference will be added.

- **Comment #16, Page 2-13, Table 2-1:** Table 2-1 does not indicate the source of data. WPI recommends the modeling scenario from which the data originates be indicated.

Response: The source of the information in Table 2-1 will be added.

- **Comment #17, Page 2-16, Figure 2-3:** One existing and one proposed well are not labeled. WPI recommends that these wells be labeled.

Response: The figure will be modified so that the wells are labeled.

- **Comment #18, Page 2-25, §2.6.2:** The last line at the bottom of page 2-25 states “federal and state ARARs are summarized in Table 2-2”; however, only federal ARARs are included in the table. WPI recommends that state ARARs be included in Table 2-2.

Response: Table 2-2 will be modified to include pertinent state ARARs in addition to federal ARARs. The State ARARs are identified on pages 2-28 through 2-35.

- **Comment #19, Page 2-40, §2.7.1:** The “MMR Plume Containment System 60% Design” is cited as OpTech 1996a; however OpTech 1996a is listed in Section 7.0 as “Draft Installation Restoration Program, Plume Containment Design Data Gap Field Work. Technical Memorandum, Massachusetts Military Reservation, February 1996.” WPI recommends this difference be reconciled.

Response: The text will be modified to cite OpTech 1996b.

- **Comment #20, Page 2-40 to 2-43, §2.7.1:** Throughout this section and other sections of the Draft Design Report, the term “plume” is used without definition or clarification regarding whether it is intended to mean the SD-5 plume, SD-5 North plume, or others. WPI recommends that all references to plume be clarified.

Response: The text will be modified as appropriate.

- **Comment #21, Page 2-41, §2.7.1:** The subsection, “Design Concentrations,” discusses the approach to calculating design influent contaminant concentrations utilized in the treatment system design. It is unclear how the calculations were made based on the information in the Draft Design Report and Appendix B. WPI recommends that the calculation of weighted averages, and their utilization in the design process, be more clearly documented.

Response: The text will be modified as appropriate.

- **Comment #22, Page 2-41, §2.7.1:** In the first bulleted paragraph under “Design Concentrations,” the process flow diagram is mentioned, but is not referenced. WPI recommends that all figures and tables mentioned in the text be referenced by number and, if necessary, volume.

Response: The text will be modified accordingly.

- **Comment 23, Page 2-43, §2.7.1:** The last paragraph in this section indicates that compounds with a higher molecular weight than benzene, although present in JP-4 in “high” concentrations, are not present in the “plume” in “high” concentrations. WPI recommends quantification of JP-4 constituents in the ground water and explanation of their potential impact on the subject treatment system. (See Comment 20).

Response: The text will be modified as appropriate.

- **Comment #24, Page 3-1, §3.0:** The text states that certain diagrams "showing the treatment system are included in Volume II." WPI recommends that the title of Volume II be provided.

Response: The text will be modified to state that certain diagrams "showing the treatment system are included in Volume II of the SD-5 North Containment System Draft Design Report."

- **Comment #25, Page 3-1, §3.1.1:** Equipment items are referred to in the text without reference to drawing numbers upon which they appear. WPI recommends that when an equipment number is cited, the appropriate drawing be referred to.

Response: The text will be modified accordingly.

- **Comment #26, Page 3-1, §3.1.1:** Reference is made to 14 extraction wells numbered 2EWP-101-1-14. These equipment numbers appear to refer to extraction well pumps. WPI recommends that this be reconciled.

Response: The text will be modified to read 2EW-101-1-14.

- **Comment #27, Page 3-1, §3.1.1:** In the second sentence reference is made to extraction well pumps 2RW-101-1-14. According to the piping legend on Drawing SD-5-1106-01A, these equipment numbers appear to refer to injection wells. WPI recommends that this be reconciled.

Response: The text will be modified to read 2EWP-101-1-14.

- **Comment #28, Page 3-2, §3.1.1:** In the second sentence reference is made to influent tank 1T-101. According to the piping legend on Drawing SD-5-1106-01A, this equipment number appears to refer to the FS-12 plume. WPI recommends that this and any other mis-numbering be reconciled.

Response: The text will be modified accordingly.

- **Comment #29, Page 3-2 to 3-6, §3.1.1 to 3.1.5:** These sections contain many references to equipment numbers. (See Comments 27 and 28).

Response: The text will be modified accordingly.

- **Comment #30, Page 3-9, §3.2.1:** Reference is made to "TCA" in the last line on the page. WPI recommends that this abbreviation be defined and included in the list of acronyms and abbreviations.

Response: TCA will be defined and included in the list of acronyms and abbreviations.

- **Comment #31, Page 3-20, §3.2.2:** Reference is made to "Volume II" in the last line of the page. (See Comment 26).

Response: See Response 24.

- **Comment #32, Page 3-21 and 3-22, Figure 3-1 and 3-2:** These figures are described in the text as illustrating the effect of plume drawdown on the adjacent ponds. However, because related information is presented on separate figures, this is difficult to ascertain. WPI recommends that the information be consolidated into one clearly labeled figure to illustrate the desired information.

Response: One figure will be used to illustrate the effect of the plume drawdown on the adjacent ponds.

- **Comment #33, Page 3-23, §3.2.2:** The second paragraph states that monitor wells will be sampled and groundwater levels will be determined to insure that the SD-5 Plume is being contained. However, according to Section 2.8.3, hydraulic monitoring to demonstrate plume capture may have limited value and this may increase the complexity and cost of performance monitoring. WPI recommends that an explanation be provided of how plume capture will be monitored in recognition of these limitations. This subject is also addressed in other portions of the Draft Design Report including Section 4.2 and Section 5.1.

Response: Details of the system monitoring will be provided under separate cover in the Performance Monitoring Evaluation Plan.

- **Comment #34, Page 3-37, §3.4:** The term "chemical perception" is used in the first paragraph. WPI recommends that, if appropriate, the term be changed to "chemical precipitation."

Response: The text will be modified accordingly.

- **Comment #35, Page 3-42, §3.4:** The last paragraph states, "The evaluation included those O&M costs that will be incurred for as long as necessary." However, no estimates of the project life are included, and, therefore, life-cycle costs can not be determined. WPI recommends that the project life and life-cycle costs be estimated and utilized in determination of life-cycle costs and alternative selection.

Response: The information requested will be provided.

- **Comment #36, Page 4-7, §4.2:** Throughout Section 4, Section 5 and Section 6, various aspects of the treatment system operation are described as manual or automatic. For example, page 4-9 of Section 4.2 states, "Operation of the carbon filters is on manual control." Page 4-7 of the same section states, "Both wells and the treatment system will be on automatic control." WPI recommends that this discrepancy be resolved and the appropriate control protocol be specified.

Response: This will be done.

- **Comment #37, Page 5-1, §5.1:** This page indicates that extraction well design data are based on Scenario 6, Version 10 of OpTech's modeling report, whereas previous information (e.g., Figure 3-2) indicates that design data are based on Scenario 6, Run 9. WPI recommends that this be resolved.

Response: The correct baseline simulation is Scenario 6, Run 1. The text and figures will be revised.

- **Comment #38, Page 5-3, §5.3:** The first sentence of Section 5.3 indicates that reinjection well design data were based on Scenario 6, Version 10. (See Comment 37).

Response: The correct baseline simulation is Scenario 6, Run 1. The text and figures will be revised.

- **Comment #1, Page 01010-1, §1.1:** 1.1.1 indicates that the work consists of construction of the facilities; however, 1.1.3 indicates that operation and maintenance shall be provided for a period of 12 months following acceptance. WPI recommends the scope of work be defined and clearly specified.

Response: The identification of which organization will maintain and operate the system has been recently determined. The period for which Jacobs will operate the system until formal turnover to the military has not been finalized.

- **Comment #2, Page 01700-1, § 1.1 and 1.3:** 1.1 states the project shall be complete in accordance with the criteria outlined in this section, which include verification of system operation, but successful operation of the system does not appear to include any operation and maintenance period, if

applicable. (See Comment 1). WPI recommends that, in conjunction with defining the project scope of work, criteria be developed to determine acceptable performance during the operation and maintenance period, if applicable.

Response: The Performance Monitoring Evaluation Plan will identify performance acceptance. See the response above for period of performance.

- **Comment #3, Page 11314-4, §2.1.2:** 2.1.2 states that pumps shall be specified in the "Extraction Well Pump Data Summary;" however no data summary sheets are provided. WPI recommends that the well summary sheets are provided. WPI recommends that the well summary sheets be included in the specifications.

Response: The pumps have been requisitioned and will be purchased shortly. The original data sheets for the pumps included a summary sheet which can be provided. To simplify maintenance, only two sizes of pumps will be purchased. After the purchase, the actual capacity of each pump can be provided.

- **Comment #4, SD5-1106, §002:** The mass balance table of this drawing contains influent contaminant concentrations different from those in the specifications. WPI recommends that the relationship between the two sets of data and the limitations of data in the drawing be explained in both the drawing and the specifications.

Response: See the response to General Comment #3, Technical Issues.

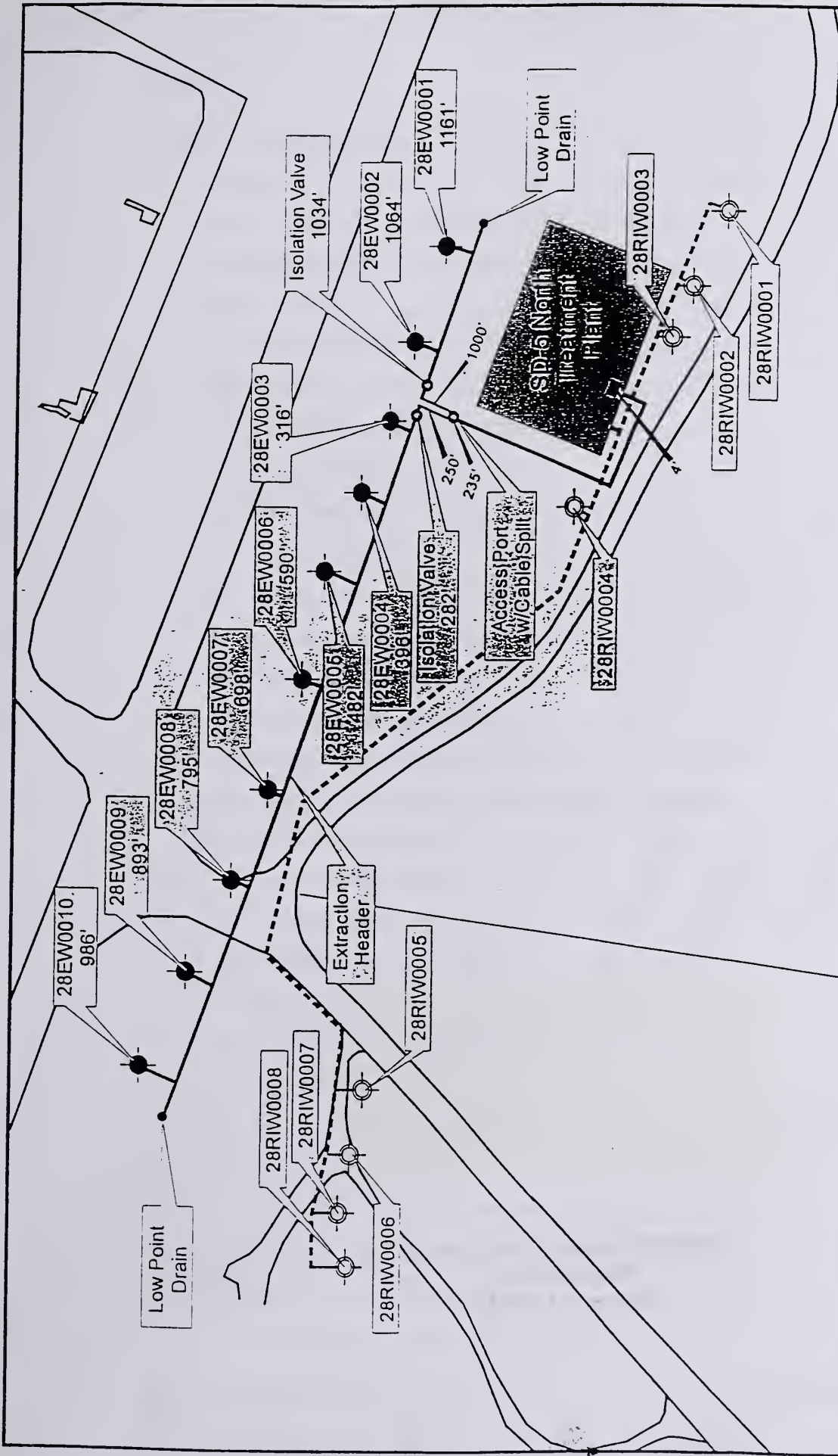
- **Comment #5, Page SD5-1106, §004:** This drawing indicated a discharge header in excess of 2500 feet in length. WPI recommends that the ability to adequately regulate flow through a single header of this length be reconsidered.

Response: If not properly designed, distribution problems can occur with multiple take-offs from a long header. To avoid these problems, the system has been designed so that the major pressure drops are in the piping to the individual reinjection wells and in the control valves in the lines to those wells. The pressure drop in the header is only a small percentage to the total pressure drop.

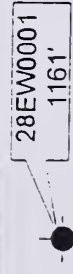
Responses to P. Brogna (Lt Col, MA ANG) Comments Dated 26 November, 1996

- **Comment #1:** There are some ongoing concerns that we have relative to test well location, gallery siting, and disposal/treatment of sludge. Discussion of these issues will continue. As of this time, we would recommend that any sludge disposal/treatment needs to be dealt with without our new plant. Due to the sensitiveness of our discharge permit and local policies, we do feel that this material should be handled by a private contract.

Response: The sludge will consist primarily of iron and manganese hydroxides, with traces of organic contaminants. The sludge will not be a hazardous waste, it will pass the TCLP. The DEP in their public comments indicated they felt the sludge could be sent to any wastewater treatment plant willing to take the sludge, including the new base facility. If discharge in the existing base facility is not practical, other disposal locations can be evaluated.



Legend



Extraction Well w/Assigned Distance

Reinjection Well



Not To Scale

JE JACOBS ENGINEERING

SD-5 North Leak Detection System Layout

Massachusetts Military Reservation
Cape Cod, Massachusetts

For Reference

Not to be taken from this room

Jonathan Bourne Public Library
19 Sandwich Rd.
Bourne, MA 02532

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ACRONYMS AND ABBREVIATIONS

EDB	ethylene dibromide
ENF	Environmental Notification Forms
EPA	U.S. Environmental Protection Agency
ETR	Extraction, Treatment, Reinjection
FAR	Federal Acquisition Regulations
FS	fuel spill
ft/day	feet per day
ft/ft	foot per foot
ft ² /day	square feet per day
GIS	Geographic Information System
gpm	gallons per minute
GPS	Global Positioning System
HAP	Hazardous Air Pollutants
HQ	Headquarters
HSP	Health and Safety Plan
IDL	Instrument Detection Limit
IDM	Investigative-derived Materials
IRP	Installation Restoration Program
JP-4	jet propellant 4
JPAT	Join Process Action Team
K	hydraulic conductivity
lbs/ft	pounds per foot
MCL	maximum contaminant level
MDEP	Massachusetts Department of Environmental Protection
MDL	Method Detection Limit
µg/l	micrograms per liter
mg/l	milligrams per liter
Mg/yr.	Million grams per year
MGD	Million Gallons per Day
MLS	multi-level sampler
MMR	Massachusetts Military Reservation



ACRONYMS AND ABBREVIATIONS

msl	mean sea level
NAAQS	National Ambient Air Quality Standards
ND	Non Detect
NESHAP	National Emission Standards for Hazardous Air Pollutants
O&M	Operation and Maintenance
OpTech	Operational Technologies Corporation
P&IDs	Process & Instrument Diagrams
PCE	Perchloroethene
PFDs	Process Flow Diagrams
PME	performance monitoring evaluation
ppb	parts per billion
ppm	parts per million
PQL	Practical Quantitation Limit
QAPP	Quality Assurance Program Plan
QPP	Quality Program Plan
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RIP	Remedial Implementation Plan
SAP	Sampling and Analysis Plan
SD	Storm Drain
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedures
SWD	Sandwich Water District
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TRET	Technical Review and Evaluation Team
TSD	Treatment Storage and Disposal
TSS	Total Suspended Solids
USAF	United States Air Force



ACRONYMS AND ABBREVIATIONS

USCS	Unified Soil Classification System
UV	ultraviolet
UVO	ultraviolet oxidation
VOC	volatile organic compound



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1.0 INTRODUCTION

This Draft Design Report has been prepared for the United States Air Force Center for Environmental Excellence (AFCEE) as part of the U.S. Air Force (USAF) Installation Restoration Program (IRP) under the Remedial Action Contract No. F41624-94-D-8115 Delivery Order No. 25. The project described herein is one component of the Strategic Plan developed by the U.S. Air Force to remediate groundwater contamination at the Massachusetts Military Reservation (MMR) in Cape Cod, MA (AFCEE 1996). Specifically, this report addresses the capture and remediation of the SD-5 (Storm Drain 5) North plume located near the southeast corner of the MMR.

Numerous combinations of wells, well spacing and pumping rates were evaluated to determine their effectiveness in capturing and containing the existing SD-5 North plume. The goal of the SD-5 North plume containment project was to identify a network of extraction and reinjection wells that will capture as near to 100% of the plume as possible without unacceptable ecological, hydrological, or other impacts. Based on the extent and characteristics of the SD-5 North plume as described in the Data Gap Technical Memorandum (OpTech 1996a) and a balanced assessment of beneficial and adverse impacts associated with groundwater pumping effects, a network of 14 extraction and 14 reinjection wells was proposed for the final design (OpTech 1996b).

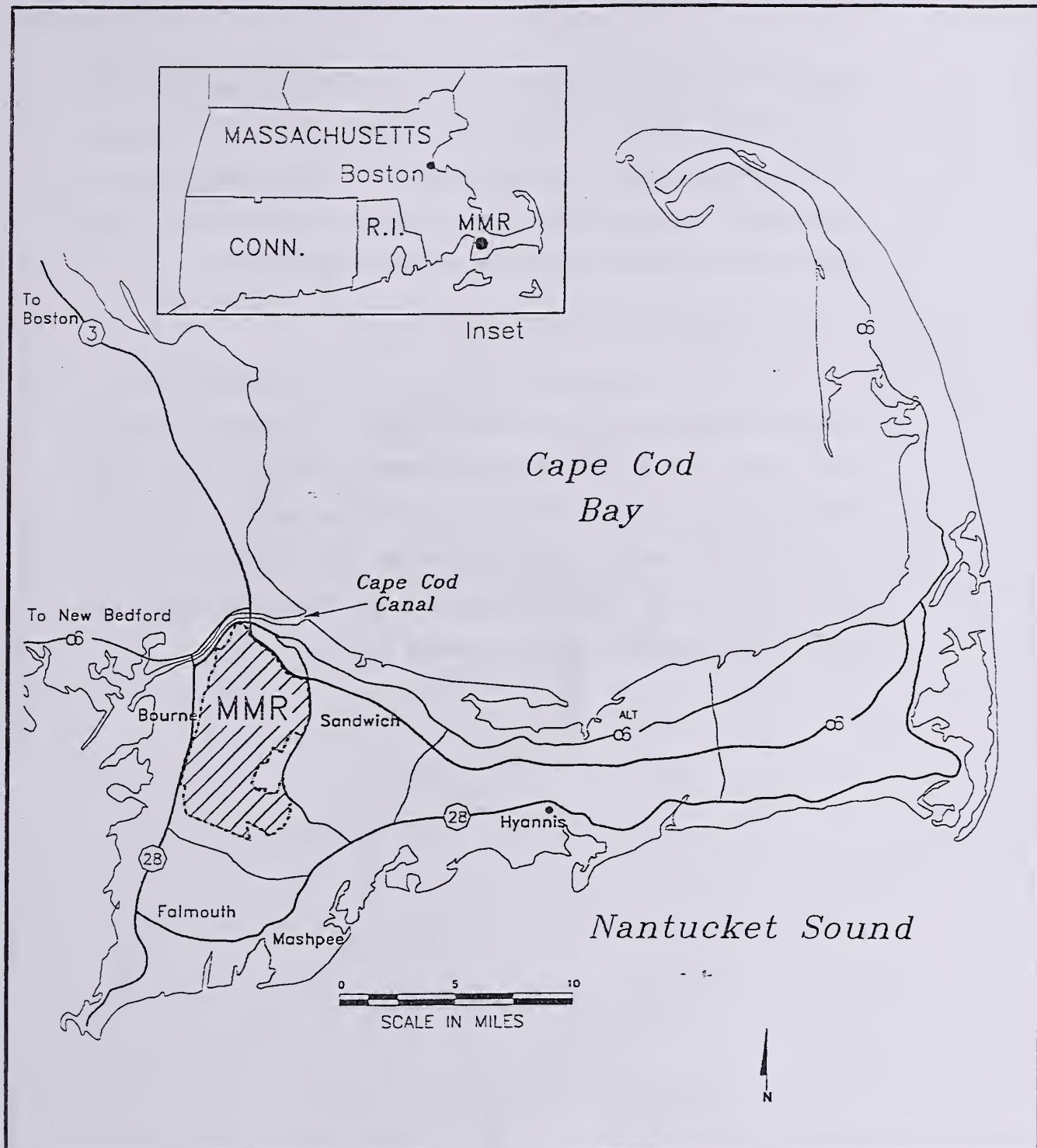
The purpose of this Draft Design Report is to present the extraction, treatment and reinjection (ETR) system design for the SD-5 North groundwater plume at the MMR site, by providing the process design basis, the treatment process description, treatment system component details, process control and containment provisions, the groundwater extraction and reinjection system details and operation and maintenance requirements. This Draft Design Report also outlines anticipated activities associated with: system design refinement; and mitigation of

existing data gaps. As a preface to the discussion of the SD-5 North ETR system design basis, a brief summary of the site and the project background is presented in the following sections.

1.1 MMR SITE LOCATION AND DESCRIPTION

MMR encompasses approximately 22,000 acres on western Cape Cod, Massachusetts, about 60 miles south of Boston (Figure 1-1). It is located in Barnstable County, and is bounded by the Towns of Bourne, Falmouth, Mashpee, and Sandwich. The reservation houses various facilities and related operations of the following Department of Defense (DOD) branches: U.S. Coast Guard, U.S. Marine Corps Reserve, U.S. Army National Guard (ARNG [Camp Edwards]), U.S. Air Force, and U.S. Air National Guard (ANG [Otis ANG Base]). Portions of the Base are used by the Veterans Administration National Cemetery, the U.S. Department of Agriculture, and the Commonwealth of Massachusetts. Most facilities are in the southern portion of the reservation. The northern portion consists of several firing ranges which the ARNG uses for training with live ammunition.

Since its establishment in 1911, a variety of activities have been conducted on MMR, including troop training and deployment; fire-fighting training; ordnance development, testing and training; aircraft and vehicle operation and maintenance; and fuels transport and storage. Most activities can be associated with either mechanized army training, maneuvers and associated functions, or with military aircraft operations, maintenance, support, and associated functions. Operations on the reservation intensified during and just after World War II (1940 to 1946). From 1955 to 1970, a substantial number of surveillance and air defense aircraft operated out of the ANG portion of the reservation. Since that time the intensity of operations has slowed, and currently a single reserve fighter squadron trains out of this airfield.



JACOBS ENGINEERING

SITE LOCATION MAP

Massachusetts Military Reservation
Cape Cod, Massachusetts

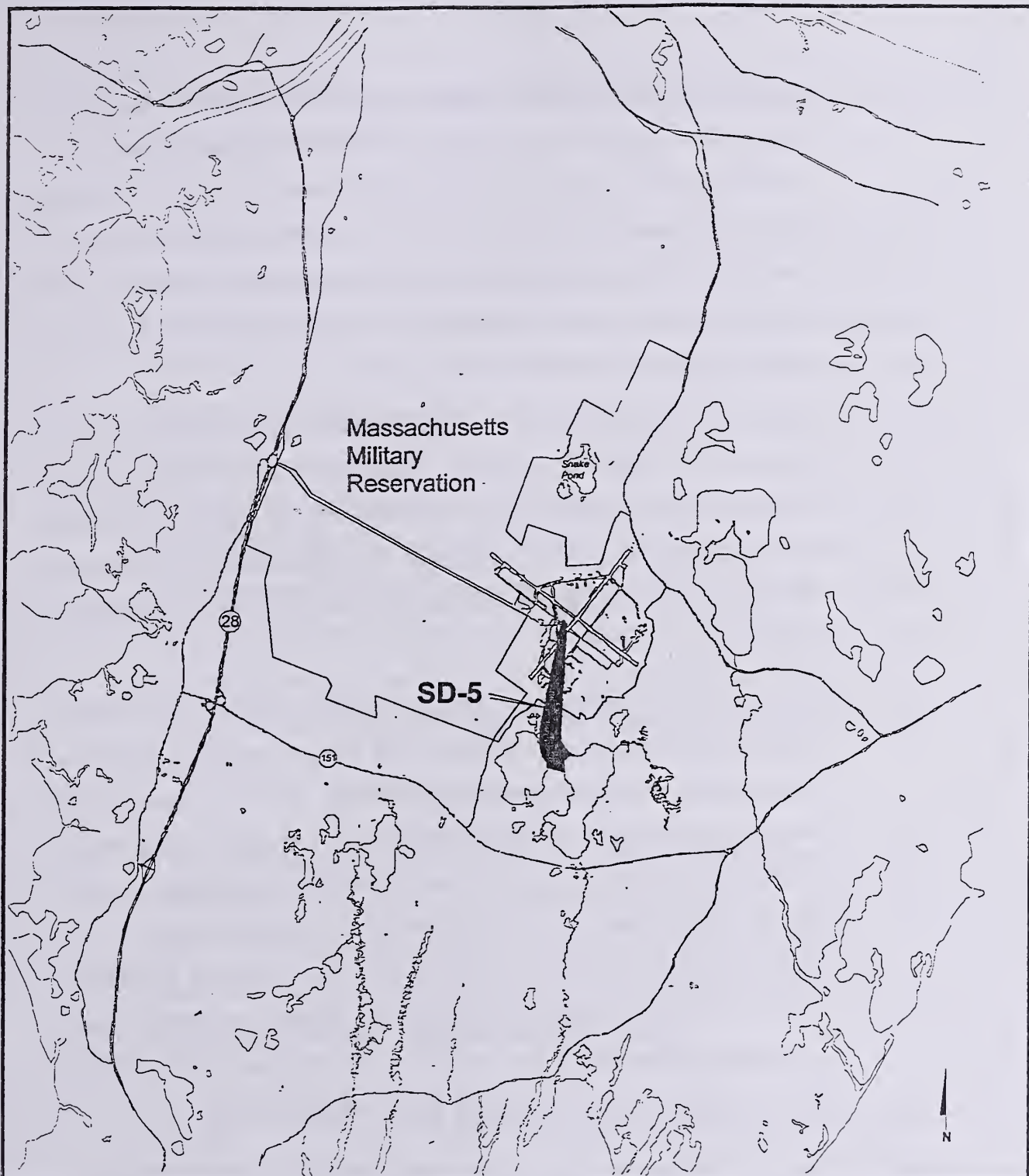
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Figure 1-1

The SD-5 North Plume Area lies in an area (see Figure 1-2) near the southeast corner of MMR, with part of the plume having migrated southward offsite and into the Town of Mashpee. The main sources of the SD-5 North groundwater contamination are approximately 3,000 feet from the nearest point along the MMR southern boundary, in the central part of the containment area.

1.2 BACKGROUND FOR SD-5 NORTH DESIGN

In 1994, the Senior Management Board, the Plume Containment Team, and representatives from the regulatory agencies agreed that a system to contain and treat 100 percent of the volatile organic compounds (VOCs) found in seven plumes at MMR, including SD-5 North, should be designed. In March 1995, OpTech, the prime contractor for the Air National Guard, initiated work on a 60 percent design for 100 percent containment of the seven groundwater plumes. The 60 percent design was completed in January 1996.



JACOBS ENGINEERING

**MASSACHUSETTS
MILITARY RESERVATION,
AND SD-5 PLUME**

*Massachusetts Military Reservation
Cape Cod, Massachusetts*

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Figure 1-2

- August 6, 1996: AFCEE, EPA, MDEP, and the TRET (hereafter referred to as Stakeholder) reviewed appendices of OpTech's SD-5 North and FS-12 modeling reports. These appendices included detailed information regarding different well scenarios that were evaluated to achieve remedial objectives in each of the plumes. One of the primary conclusions of the August 6, 1996 meeting was that an additional meeting was required to review the main body of the OpTech Modeling Report.
- August 28, 1996: Stakeholders reviewed the main body of OpTech's SD-5 North and FS-12 modeling reports. Model formulation, calibration, and sensitivity analysis strategies were discussed during the meeting. Following the August 28, 1996 meeting, stakeholders requested specific SD-5 North and FS-12 meetings to evaluate in more detail the design basis of the proposed ETR systems.
- October 8, 1996: Stakeholders discussed potential chemical and hydraulic impacts that pump and treat systems could have on ecological resources. Potential impacts included changes in temperature, pH, total organic carbon, dissolved oxygen, essential nutrient concentrations, and water table variations. Additions to the treatment process may be identified in the future as site-specific ecological data is collected and evaluated over the next year.
- October 11, 1996: Stakeholders were presented the design basis of the SD-5 North ETR system. Specific topics of discussion included the appropriateness of modeling parameters, the need to limit plume dispersion, and the need to fill data gaps before construction of the SD-5 North ETR system.

Based on input from stakeholders over the past several months, the SD-5 North ETR system design is anticipated to proceed. Although many issues have been discussed, and additional modeling and data gap efforts were suggested by stakeholders, no critical flaws in the SD-5 North ETR system design have been

well fences extend approximately 400 feet along South Outer Road where the SD-5 plume crosses the MMR boundary.

From March 1996 to June 1996, OpTech and their modeling subcontractor P²T (formerly Environmental Consulting Engineering [ECE]) performed a number of groundwater simulations to identify a groundwater extraction system to maximize capture of the SD-5 North plume while minimizing impacts to the Western Aquafarm and PFSA plumes and recirculation of treated groundwater. Based on the results of the computer modeling performed by P²T, a network of 14 extraction and 14 reinjection wells was proposed for the SD-5 North groundwater extraction network. The computer modeling that provided the basis for that network is described in the Plume Containment Design Groundwater Modeling Report (OpTech 1996b) submitted in late August 1996. An appendix to that report which focused on the SD-5 North site was submitted in July 1996. Section 2.4.1 provides a summary of the groundwater modeling efforts performed by P²T for SD-5 North.

In May 1996, during completion of the SD-5 North modeling efforts by OpTech and P²T, the U.S. Air Force (through AFCEE) became the lead agency for the MMR. As part of the plume response strategy, Jacobs Engineering Group Inc. (Jacobs) has been contracted to design plume containment/remediation systems for groundwater plumes at MMR, including SD-5 North.

Since May 1996, when Jacobs became the prime AFCEE contractor at MMR, there have been five meetings regarding critical issues related to the SD-5 North ETR system. A brief synopsis of the meetings is included below:

- May 1996: AFCEE, TRET, JPAT reviewed and adopted the 14 extraction well and 14 reinjection well ETR system. This became the basis for upcoming engineering.

- August 6, 1996: AFCEE, EPA, MDEP, and the TRET (hereafter referred to as Stakeholder) reviewed appendices of OpTech's SD-5 North and FS-12 modeling reports. These appendices included detailed information regarding different well scenarios that were evaluated to achieve remedial objectives in each of the plumes. One of the primary conclusions of the August 6, 1996 meeting was that an additional meeting was required to review the main body of the OpTech Modeling Report.
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Based on input from stakeholders over the past several months, the SD-5 North ETR system design is anticipated to proceed. Although many issues have been discussed, and additional modeling and data gap efforts were suggested by stakeholders, no critical flaws in the SD-5 North ETR system design have been

identified. The next section outlines the basis of the recommended SD-5 North ETR system design.

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2.0 DESIGN BASIS

The SD-5 North ETR system has a number of objectives (Strategic Plan AFCEE, 1996) which include:

- Design, construct, and operate a full-scale ETR system;
- Contain, capture, and remediate the SD-5 North plume;
- Minimize adverse impacts on Ashumet and Johns Ponds and their surrounding environment;
- Monitor performance of treatment system;
- Minimize disturbance by the remedial system on the Western Aquafarm, Ashumet Valley, and CS-10 East plumes. (This objective may not be achievable for a portion of the Western Aquafarm due to its proximity to the SD-5 North plume and containment system);
- Minimize disturbance to private property;
- Monitor performance of treatment system; and
- Monitor groundwater quality to assess performance and assist future design at other sites.

These objectives, in combination with regulatory requirements and the site conditions form the basis for the SD-5 North ETR system design. The last two bullets identify performance monitoring objectives and are not addressed in this report. These topics will be presented in the Draft Performance Monitoring Plan to be submitted in December 1996. As discussed in Section 1.2, Background For SD-5 North Design, a network of 14 extraction and 14 reinjection wells was determined to provide a satisfactory balance of project objectives, and that system was described in the Plume Containment Design Groundwater Modeling Report



in August 1996. In addition, as discussed in Section 1.2, Background For SD-5 North Design, following submittal of the Plume Containment Design Groundwater Modeling Report in August 1996, various aspects of the design basis for the SD-5 North ETR system have since been discussed in four separate technical meetings. These meetings have resulted in the commitments for additional data collection activities and modeling simulations to verify or refine the proposed SD-5 North ETR system network of 14 extraction and 14 reinjection wells. Also, discussions with private property owners regarding long-term access and right of entry for portions of the SD-5 North ETR system located on private property are ongoing. As a result, this Draft Design Report presents the network of 14 extraction and 14 reinjection wells as the basis for the SD-5 North ETR system design with the understanding that finalizing the design will be an iterative process. The following items may be used to refine the SD-5 North ETR system design basis prior to construction, if necessary:

- Jacobs is in the preliminary stages of conducting an aquifer pump test at SD-5 North. Section 2.5.4 provides more detail on planned pump test activities.
- Jacobs will collect additional field data as described in Section 2.5.1, to better define the baseline and contaminant concentrations of the plume.
- Jacobs will continue to address property access issues to ensure that construction of the SD-5 North ETR system will alleviate private property owner concerns while meeting the project schedule.
- Jacobs will continue to evaluate ecological issues related to construction of the SD-5 North ETR system. Section 2.5.5 provides more detail on ecological issues related to SD-5 North.
- Stakeholder input on the SD-5 North design will continue to be evaluated.

As additional information becomes available, Jacobs will update the current SD-5 North groundwater model to refine groundwater extraction and reinjection well



locations, as necessary. Final modeling simulations, including modifications to the SD-5 North ETR system proposed herein, will be presented to stakeholders for evaluation and approval.

It is important to recognize that although design refinements are anticipated, these refinements are not expected to significantly change the conceptual basis for the SD-5 North ETR system described in this Draft Design Report. To compensate for design uncertainties, the SD-5 North ETR system design includes flexibility in sustainable system operating flow rates, and acceptable influent water quality. The following sections include a discussion of site conditions, modeling efforts, data gap collection efforts, treatment plant water quality considerations, and design limitations related to the basis of the SD-5 North ETR system design.

2.1 SD-5 North Plume

The SD-5 North plume source area lies in an area near the southeast corner of MMR, with part of the plume having migrated southward off site and into the town of Mashpee. The main sources of the SD-5 groundwater contamination are approximately 3,000 feet from the nearest point along the MMR southern boundary, in the central part of the containment area. The source area is bounded by North Inner Road, Lingley Avenue, and Base Runway 5. The sources of contamination include: the non-destructive inspection laboratory (NDIL) sump; the Corrosion Control Shop; and the sumps in Hangars 3122 and 3192. The area around Hangar 3140 could also be a contamination source. These sources, and the movement of contaminants in a stormwater drainage ditch leaving the source area toward the south, and the infiltration of the contaminants into the groundwater, have produced a narrow plume of chlorinated solvents and EDB approximately 10,000 feet long.

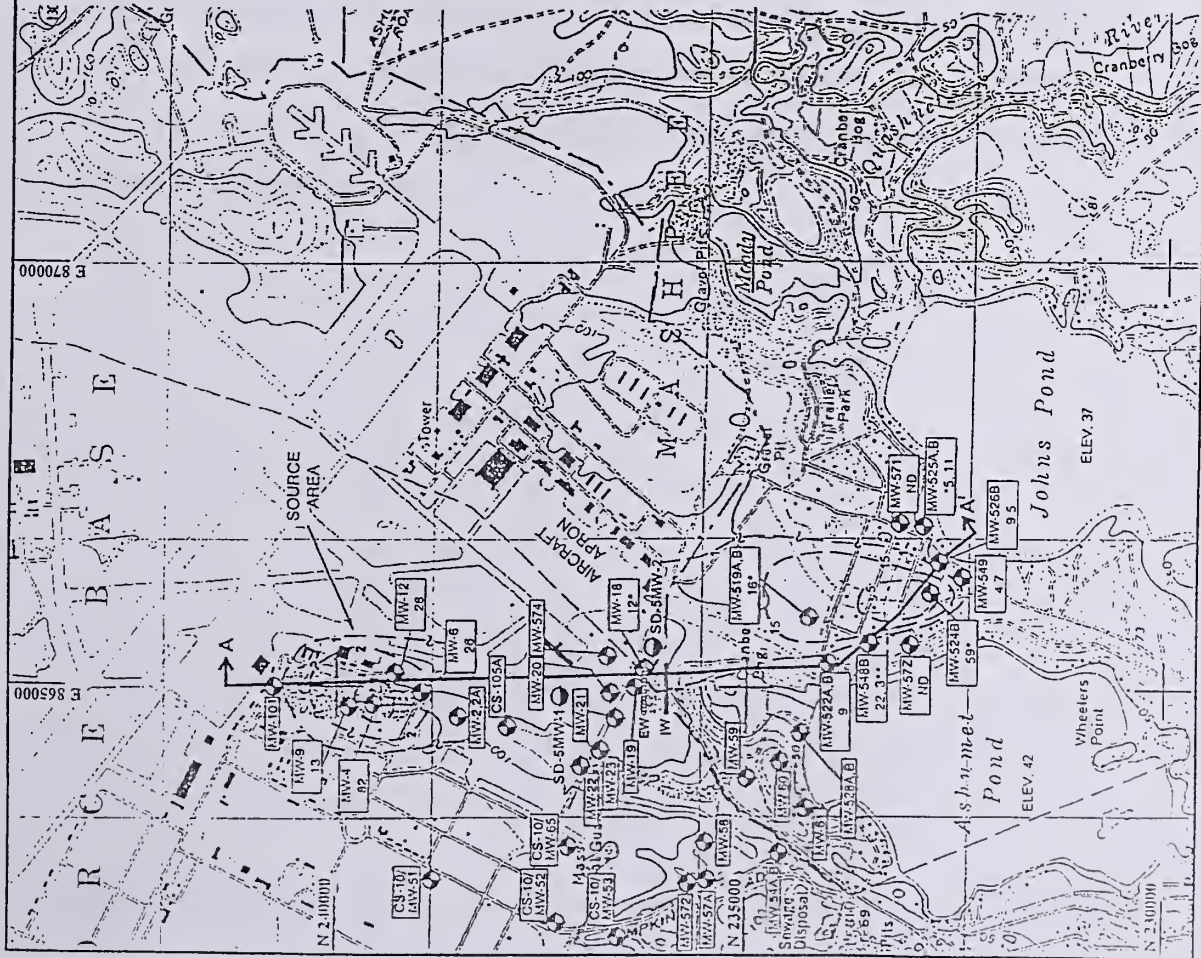
The majority of the SD-5 plume is migrating through fine to coarse-grained sands, although the geology at the distal end of the plume is characterized by fine sands,



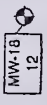
silt, and clay. As the SD-5 plume migrates, the depth generally increases. The plume bottom is approximately 35 feet below the water table (25 msl) near the source, approximately 70 feet below the water table (-20 msl) at the proposed extraction fence, and approximately 120 feet below the water table (-80 msl) near the leading edge.

The primary contaminants in the SD-5 plume are chlorinated solvents (TCE, PCE, and 1,2-DCE) which all have been detected at concentrations above maximum contaminant levels (MCLs). Maximum concentrations to date are; 82 µg/l TCE at MW-4, 6 µg/l PCE at MW-19A, and 220 µg/l 1,2-DCE at MW-4 (see Figure 2-1). A secondary contaminant, ethylene dibromide (EDB) is also sporadically detected in the SD-5 North plume. EDB has been detected at well MW-21 near the proposed extraction well fence location. The source of the EDB is unknown. Since TCE has the greatest aerial extent of MCL exceedance of the three chlorinated solvent contaminants, the boundaries of TCE are shown on Figure 2-1.

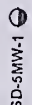
An additional factor complicating interpretation of the SD-5 plume is its proximity to portions of the Western Aquafarm and the Petroleum Fuels Storage Area (PFSA). These plumes located adjacent to the SD-5 North plume, are illustrated on Figure 2-2.



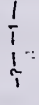
LEGEND



Existing groundwater monitoring well with concentration of TCE in $\mu\text{g/L}$
 * Exhibited a lower value of TCE during Data Gap Investigation
 ** Exhibited a lower value of TCE during SERGOU RI



Proposed cluster groundwater monitoring well



Isoconcentration contour line of TCE (concentration in $\mu\text{g/L}$), queried where uncertain



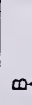
Proposed line of 14 extraction wells



Proposed line of 14 reinjection wells



Cross section A-A' at Storm Drain-5 (see Figure 2.2 for cross section A-A')



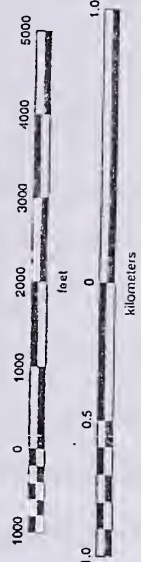
Cross section B-B' at Storm Drain-5 (see Figure 2.3 for cross section B-B')



Massachusetts Military Reservations boundary

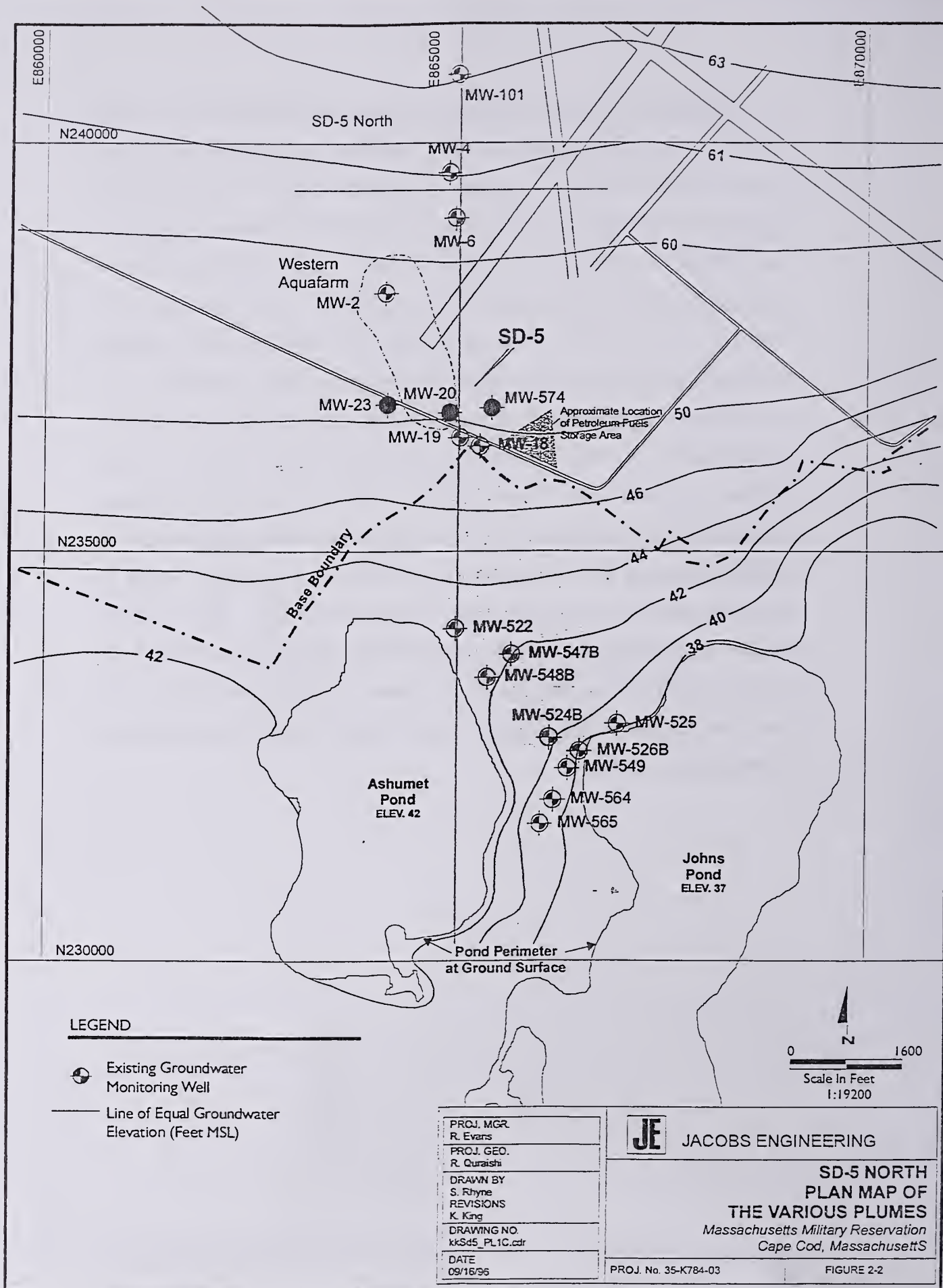
NOTES:

- Topography from USGS Pocasset Massachusetts Quadrangle, 7.5 minute series. Project coordinates superimposed on the quadrangle.
- Topographic contour interval = 10 feet
- National Geodetic Vertical Datum
- Analytical data based on the results of the Remedial Investigation activities, SERGOU (1989-1993), and Plume Containment Design Data



PROJ. MGR. R. Evans	JACOB'S ENGINEERING GROUP, INC. Pasadena, California
PROJ. GEO. R. Oursch	MASSACHUSETTS MILITARY RESERVATIONS Cape Cod, Massachusetts
DRAWN BY J. Lawrence	Storm Drain Disposal Site No. 5 (SD-5 North)
DRAWING NO. 1119K781-01 CDR	Data Gap Investigation for Evaluation of Plume Containment System
MADE FROM	"TCE MCL Exceedance Isoconcentration Map"
DATE 02/11/96	FIGURE 2-1

The contaminants of concern at Western Aquafarm are benzene and EDB. A plan view of the area where benzene, toluene, ethylbenzene, and xylenes (BTEX) has been detected is illustrated on Figure 2-2. Screened auger and sampling data collected by OpTech during the data gap field effort detected benzene at concentrations exceeding the MCL. Benzene was detected at well FTA-2/MW-2, upgradient of the extraction well fence, at a concentration of 6.9 $\mu\text{g/l}$. EDB was detected in one well, MW-20 at a concentration of 0.03 $\mu\text{g/l}$, exceeding the MCL for EDB (OpTech 1996a). The BTEX plume extends from the presumed source area (Western Aquafarm) situated south-southwest of the SD-5 source area to approximately well MW-20. In general, it appears that the distal end of the Western Aquafarm plume (in the vicinity of the well MW-20) is coalescing (areally) with the SD-5 plume. It is to be noted however, that insufficient data is available regarding the vertical distribution of the Western Aquafarm plume to assess the degree to which the plumes coalesce with depth. The toe of the Western Aquafarm plume is situated north-northwest of the proposed ETR fence for SD-5 North. To be safe, the SD-5 treatment system has been designed to handle any benzene or EDB that may be pulled into the extraction wells from the Western Aquafarm plume.



The PFSA is located east of the proposed extraction well fence (Figure 2-2). Fuel-related contaminants have been detected in shallow wells in the vicinity of the source area. The eastern edge of the extraction well fence may draw in some of these fuel contaminants, such as ethylbenzene and xylenes, found to contain 16 µg/l ethylbenzene and 550 µg/l xylenes.

The SD-5 treatment system has been designed to handle these contaminants if they enter the extraction well fence.

2.2 SD-5 NORTH GEOLOGY

The unconsolidated deposits profile underlying the SD-5 North plume area predominantly consists of poorly graded, fine- to coarse-grained glacial outwash sands of the Mashpee Pitted Plain, with occasional layers of well-graded, fine- to coarse-grained sand or gravel and leuticular deposits of silt and clay. Off base (southern portion of the plume), the Mashpee Pitted Plain deposits grade into well-graded fine- to coarse-grained sand with lenses of silt and clay, and fine to coarse gravel and cobbles. Near the northern end of Johns Pond and between Johns and Ashumet Ponds, silt and clay layers become more prevalent with depth. The overall Unified Soil Classification System (USCS) designation for the deposits is SP: poorly-graded sand or gravelly sand with little or no fines. The deposits are typical of high-energy fluvial environments, distinctive of pro-glacial outwash plains. Fine-grained, glaciolacustrine sediment and basal till have been described below the unconsolidated sediments of the Mashpee Pitted Plain (LeBlanc 1984, and HAZWRAP 1995).

Geologic interpretations of the SD-5 Study Area are based on subsoil sampling of both the unsaturated and saturated zones, boring log data obtained from split-spoon samples, auger cuttings, and variations in drill rates. The interpretation of stratigraphy in the vicinity of SD-5 plume has been based primarily on auger cuttings.



2.3 SD-5 NORTH HYDROGEOLOGY

The unconfined Mashpee Pitted Plain sand aquifer underlies the entire SD-5 plume area. Groundwater moves from the SD-5 source areas under the southern portion of runway No. 5 south towards Johns Pond.

In general, the groundwater flow for the on-Base portion of SD-5 is north to south, changing to west to east between Johns and Ashumet Ponds. This apparent shift in groundwater flow direction is due to the difference in elevation between the ponds. Depth to groundwater in the on-Base SD-5 area ranges from 50 to 60 feet below ground surface (bgs). The elevations of Johns and Ashumet Ponds are approximately 37 and 42 feet above mean sea level (msl) respectively. The average horizontal gradient is approximately 0.006 foot per foot (ft/ft).

Slug test values for hydraulic conductivity (K) ranged from 1 to 183 feet per day (ft/day) across the SD-5 plume area.

2.4 SD-5 NORTH MODELING

Groundwater modeling has served as one of the primary tools for evaluating the basis of the SD-5 North ETR system design. By inputting the site hydrogeologic conditions with modifications as appropriate to achieve model calibration, and using particle tracking to simulate the extent of the TCE plume above MCLs, various extraction and reinjection well pumping and injection rates, locations, and screen depths have been simulated to aid in the design of the SD-5 North ETR system. The Plume Containment Design Groundwater Modeling Report (OpTech 1996b) provides a detailed discussion of SD-5 North model development and utilization for the SD-5 North ETR system design. The following sections provide a summary of modeling efforts for SD-5 North, justification for proposed extraction and reinjection well locations, pumping/injection rates, and screen intervals, modeling uncertainties, and anticipated future modeling efforts.



2.4.1 Summary of Modeling Efforts for SD-5 North

As discussed in Section 1.2, Background for SD-5 North Design, the initial objective of groundwater modeling efforts for MMR was to capture 100 percent of all groundwater contamination from seven groundwater plumes, including SD-5 North. Following submittal of the 60 percent design it was determined that 100 percent capture of all groundwater contamination at MMR could result in adverse impacts to Cape Cod's sensitive ecological system and sole source aquifer. As a result, the main objectives of the groundwater modeling efforts following submittal of the 60 percent design were the following, in order of importance (OpTech 1996):

- Maximize contaminant capture of the SD-5 North plume, protecting downgradient receptors with containment wells toward the leading edges of the plume;
- Minimize hydrologic impacts on nearby surface water (mainly Ashumet and Johns Ponds);
- Minimize influence on migration of the CS-10 East and Ashumet Valley plumes;
- Emphasize constructability and minimize impact to surrounding land;
- Minimize recapture of injected, treated groundwater; and
- Minimize pumping rates.

Since some of these objectives are conflicting, the basis of the SD-5 North modeling efforts was to achieve a balance between the objectives.

In order to identify an efficient ETR system that satisfied the established design criteria, groundwater modeling was conducted using the code FRAC3DVS (Therrien, R. et al., 1994). Hydraulic conductivity values used for SD-5 North



modeling were developed from slug tests and adjusted during model calibration to obtain an acceptable match between modeled and observed groundwater elevations and stream flow measurements. To provide an additional model check, particle tracking was also performed to help evaluate if the model accurately predicted with reasonable accuracy the rate and direction of plume migration over time. Modeling details are provided in OpTech, 1996b.

Following model construction and calibration, six different ETR schemes were developed and evaluated. The percent of contaminant mass captured and water table drawdown were two critical evaluation criteria for the alternatives assessed by the model.

The following bullets provide a brief summary of the simulations performed:

- Scenarios 1 and 2 simulated by the model minimized well spacing, recirculation of treated water and capture of the Western Aquafarm and PFSA plumes. Scenarios 1-2 did not meet evaluation criteria and location of extraction wells in the flightline was problematic.
- Scenarios 3 and 4 simulated by the model emphasized location of the extraction fence along South Outer Road while minimizing capture of the Western Aquafarm plume and recirculation of treated water. Scenarios 3 and 4 still did not meet evaluation criteria.
- Scenarios 5 and 6 re-oriented extraction and reinjection fences parallel to equipotential lines, allowed for capture of Western Aquafarm plume and recirculation of treated water if minimal disturbance of the surface water bodies downgradient occurred, evaluated differential pumping and injection rates and offset screen depths to enhance capture and reduce recirculation, and re-evaluated plume seeding and refined model to more closely represent gradients. Scenario 6 provided the best balance among the criteria selected for evaluation.

Scenario 6 consists of 14 extraction wells pumping at a design rate of approximately 355 gpm, and 14 injection wells pumping the same volume back into the aquifer following treatment. Scenario 6 is the recommended basis for the SD-5 North ETR well network presented in this Draft Design Report. Table 2-1 presents the well locations, screen depths, and pumping rates for Scenario 15.

2.4.2 Well Locations

Figure 2-1 outlines a plan view of the network of 14 extraction and 14 reinjection wells proposed for the SD-5 North ETR system design. The well field consists of two principal components, a toe extraction fence to capture the northern portion of the SD-5 plume (extraction wells EW-1 through EW-14) and a toe reinjection well fence (IW-1 through IW-14) to reinject the treated water back into the aquifer. The toe extraction well fence is designed to capture all groundwater contamination above MCLs attributed to the SD-5 North source area. The entire extent of capture required to achieve this objective is generally defined by TCE, the largest groundwater plume at SD-5 North as outlined on Figure 2-3. The SD-5 North toe reinjection well fence is designed to minimize plume dispersion, recirculation of treated water, and impacts to Ashumet and Johns Ponds.



TABLE 2-1
SD-5 NORTH EXTRACTION/REINJECTION WELLS

Extraction Wells (355 gpm)

Northing (coordinates)	Easting (coordinates)	Top of Screen (ft msl)	Bottom of Screen (ft msl)	Pump Rate (gpm)
236220	864620	0	-40	35
236220	864660	0	-40	35
236230	864720	0	-40	20
236230	864770	0	-40	20
236220	864820	0	-40	20
236250	864860	0	-40	20
236260	864920	0	-40	20
236270	864960	0	-40	20
236280	865010	0	-40	20
236290	865060	0	-40	20
236290	865110	0	-40	20
236300	865160	0	-40	30
236300	865210	0	-40	35
236320	865260	0	-40	40

Injection Wells (355 gpm)

Northing (coordinates)	Easting (coordinates)	Top of Screen (ft msl)	Bottom of Screen (ft msl)	Pump Rate (gpm)
235900	864620	20	-20	25
235900	864670	20	-20	25
235900	864720	20	-20	25
235930	864770	20	-20	25
235930	864820	20	-20	30
235930	864860	20	-20	30
235950	864910	20	-20	30
235960	864970	20	-20	30
235960	865010	20	-20	30
235970	865060	20	-20	25
235980	865120	20	-20	20
235990	865170	20	-20	20
235980	865220	20	-20	20
236000	865260	20	-20	20

Notes:

ft msl feet mean sea level
gpm gallons per minute



Based on the groundwater modeling results for SD-5 North and discussions with stakeholders, several areas still require additional characterization to ensure the extent of all plumes within the SD-5 North area are accurately defined and the proposed extraction and reinjection well scheme is sufficient to meet the objectives of complete capture of all SD-5 North groundwater contamination above MCLs. These areas include the extent of EDB contamination upgradient of the proposed ETR fence, the horizontal and vertical extent of the SD-5 North plume between MW-6 and the proposed ETR fence, and the toe of the Western Aquafarm plume in relationship to the proposed ETR fence. Section 2.5.1 provides a detailed discussion of data collection activities that will be performed prior to construction of the SD-5 North ETR system to address these data gaps.

2.4.3 Screen Locations

Recommended screen depths for the extraction and reinjection well network are shown in Table 2-1. Figure 2-3 provides a cross sectional view of screen depths for select extraction and reinjection wells. Recommended screen depth intervals for all extraction wells in this Draft Design Report are from 0 feet above mean sea level (msl) to 40 feet below msl. This screen depth was selected to capture the maximum section of plume contamination while attempting to minimize capture of the Western Aquafarm plume. Based on groundwater modeling efforts, the proposed extraction well screen depths are capable of capturing the entire extent of groundwater contamination above MCLs at SD-5 North with the possible exception of one area, the extreme eastern portion of the plume. However, since the plume boundary above MCLs in this area is uncertain, additional data collection activities will be conducted prior to construction of the SD-5 North ETR system to verify the plume dimensions. In addition, to address concerns by stakeholders that the proposed extraction fence could enhance vertical plume migration, additional modeling runs are currently being performed to evaluate this

possibility. Following additional modeling efforts and data collection and review, design refinements will be made if necessary.

Recommended screen depths for reinjection wells range from 20 feet above msl to 20 feet below msl. Based on groundwater water modeling efforts, the proposed depth of the reinjection well fence was selected to minimize plume dispersion, capture of the Western Aquafarm plume, and circulation of reinjected water to the extraction well fence.

As described in Section 2.5.1, additional data collection activities will be conducted prior to construction of the SD-5 North ETR system. This data will include groundwater screening and lithology information to better define appropriate screen intervals for extraction and reinjection wells.

LEGEND

Water table

Existing monitoring well

Proposed cluster groundwater monitoring well

Well screen ID

Fine to coarse-grained sand

Fine sand, silt, and/or clay

Monitoring well groundwater sample with TCE concentration

Isosconcentration contour

Not sampled

Not detected

TCE concentrations in $\mu\text{g/L}$

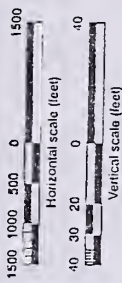
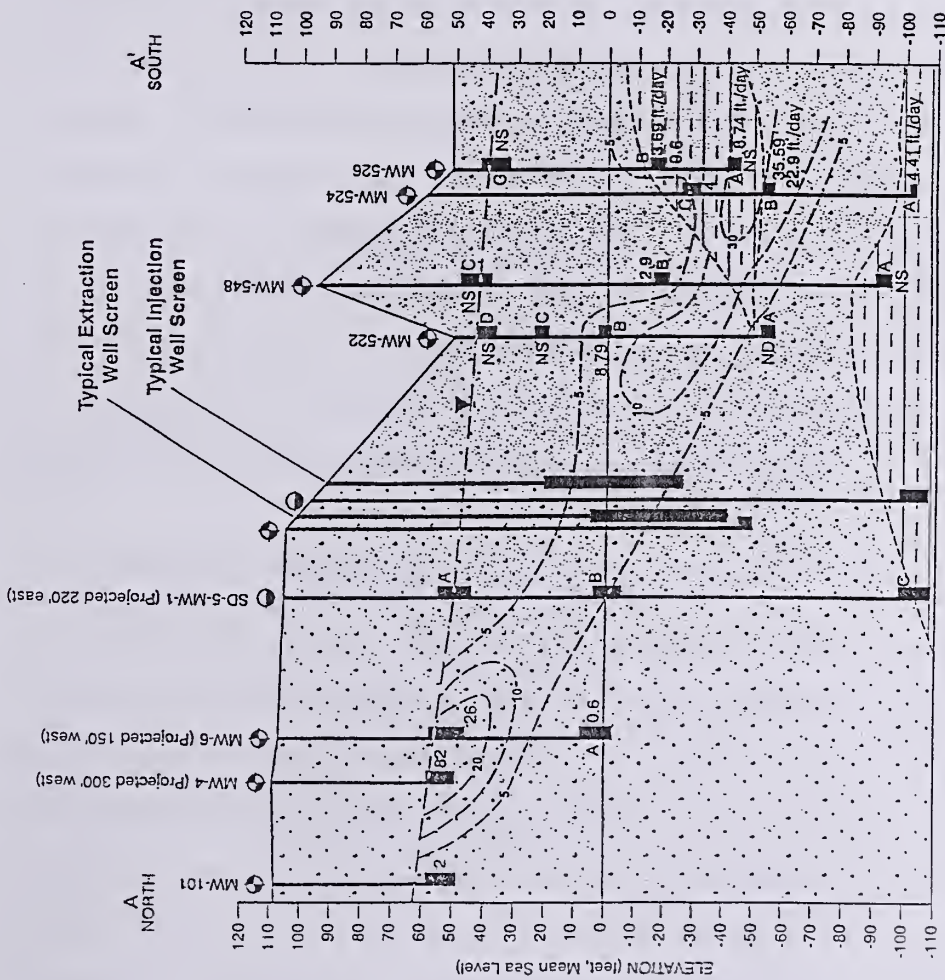
Hydraulic conductivity values (K , ft./day) reported in SERGOU RI, 1994

NOTES:

a) See Figure 2-1 for location of cross section A-A'

b) Screen interval depths and diameter for proposed cluster wells are included in Table 1

c) TCE analytical and hydrogeologic data from Data Gap Summary Report, SD-5, February 1996 (OP TECH), Remedial Investigation Report (SD-5), January 1992



PROJECT NO.	35-K781-03	FIGURE 2-3
DATE	09/11/96	
PROJECT NAME	JACOBS ENGINEERING GROUP INC.	
PROJECT LOCATION	Pasadena, California	
PROJECT DESCRIPTION	MASSACHUSETTS MILITARY RESERVATIONS	
PROJECT ADDRESS	Cape Cod, Massachusetts	
PROJECT DRAWING NO.	Storm Drain Disposal Site No. 5 (SD-5 North)	
PROJECT DRAWING NO.	Data Gap Investigation for Evaluation of	
PROJECT DRAWING NO.	Plume Containment System	
PROJECT DRAWING NO.	"Hydrogeologic Cross Section A-A' with TCE	
PROJECT DRAWING NO.	MCL Exceedance Isoconcentration"	

2.4.4 Pumping and Reinjection Rates

Recommended pumping and reinjection rates were iteratively selected by performing groundwater modeling and particle tracking simulations. As described in Section 2.4.1, Summary of Modeling Efforts For SD-5 North, six different well network configurations were tested before recommending Scenario 6. The pumping and reinjection rates recommended in Table 2-1 achieved a satisfactory balance between stakeholder objectives. Based on the modeling results, the recommended extraction well pumping rates will produce less than 0.3 feet of drawdown at a distance of 50 feet downgradient from the extraction wells while still maintaining capture of the groundwater plume. Drawdown at distances greater than 50 feet downgradient from the extraction wells will be minimal. Recommended injection rates for reinjection wells are projected to have even less impact on groundwater elevations at SD-5 North. Groundwater modeling results indicate that at a distance of 50 feet downgradient from the reinjection wells, less than 0.25 feet of mounding will occur at the recommended reinjection well injection rates. Mounding at distances greater than 50 feet will be minimal. The anticipated changes in groundwater elevations at SD-5 North from the proposed SD-5 North ETR system are much less than seasonal variations in groundwater elevations measured at MMR.

2.4.5 Modeling Uncertainties

Groundwater modeling was utilized as one of the primary tools in developing the proposed SD-5 North ETR system. However, it is important to recognize that all modeling efforts contain uncertainty. The Plume Containment Design Groundwater Modeling Report (OpTech 1996b) outlines many of the primary uncertainties in groundwater modeling. By performing additional data collection activities prior to construction and providing considerable flexibility in the operating flow and influent water quality range that the SD-5 North ETR system can handle, it is anticipated that design uncertainties can be managed effectively.



2.4.6 Additional Modeling Efforts

Jacobs is currently working with stakeholders to address comments on previous groundwater modeling efforts. In addition, as data becomes available the groundwater model for SD-5 North will be updated. Following completion of data collection activities and incorporation of stakeholders comments, Jacobs will present the results of the final groundwater modeling simulations, including recommendations for any design refinements.

2.5 DATA COLLECTION ACTIVITIES

To compensate for potential design uncertainties, the design approach includes additional data collection efforts before and during the initial construction period. These efforts are described in this section.

2.5.1 Preconstruction Plume Definition Data Collection

The following data collection efforts are planned to assess the validity of the plume definition and ETR fence geometry proposed as the basis for design.

Inorganic data collection at select wells is currently ongoing as part of a site-wide inorganic investigation. As part of this effort VOC analysis is also being performed at select wells at SD-5. This data will be incorporated into the evaluation of magnitude and extent of the contaminants of concern prior to the construction activities.

EDB has been detected at levels slightly above acceptable regulatory levels in some wells. Groundwater samples will be collected from existing in-plume monitoring wells and at the groundwater well locations described below to determine the significance of EDB (maximum concentration, average concentration, and volume of EDB-impacted groundwater). It is anticipated that



this sampling will be conducted during the design analysis phase prior to construction.

To assess contaminant distribution, up to five new monitoring wells with multiple sampling depths are proposed between existing wells MW-20 and MW-6 (see Figure 2-1). Five screened auger borings (or alternate technology e.g., Hydropunch II™) will be advanced prior to well installation to further delineate the vertical limits of the plume upgradient and cross-gradient of the proposed extraction fence location. Groundwater samples will be collected at five foot intervals from 50 feet above msl to 80 feet below msl in the borings. The elevation of the water table at the proposed extraction fence is at approximately 50 feet above msl. Depth-to-water near the SD-5 source area is approximately 60 feet (see Figure 2-3). Groundwater samples will be analyzed for the contaminants of concern.

If groundwater screening results do not agree with the anticipated plume dimensions the need to modify the design (well screen intervals and pumping rates) will be assessed and evaluated in consultation with stakeholders. Any suggested modifications will be submitted for review and approval. The groundwater screening program may be initiated during the design data analysis phase prior to system construction.

The groundwater screening program will proceed as follows:

- The groundwater screening location east of the proposed extraction fence (Location No. 1) will be drilled first to assess the potential presence (and vertical extent) of contamination (see Figure 2-1). The data will be used to verify the proposed eastern limit of the fence and screen depths. Based on the groundwater screening results, it is anticipated that a well cluster (three wells) will be installed at depths above, within, and below the plume (if detected), or at depths above, within, and below the proposed extraction well screen



interval if no contamination is detected during the groundwater screening. It is assumed that these wells will become part of the performance monitoring network for the extraction/injection system.

- Groundwater screening Location No. 2, situated north of the proposed extraction fence, will be drilled after drilling and sampling at Location No. 1 (see Figure 2-1). The purpose of this groundwater screening location is to characterize the SD-5 plume between the extraction fence and well MW-6 and further define the vertical limits of contamination. Based on the groundwater screening results, it is anticipated that two wells will be installed (one within the plume and one below the plume). If contamination is not detected at this screening location, one well will be installed at the interpolated plume depth based on the plume vertical profile as determined by adjacent wells (it is likely that this well will be screened at approximately 0 to 10 feet above msl).
- Groundwater screening Locations No. 3 and 4 will be drilled following collection and analysis of screening data from Location No. 2. These groundwater screening borings will be advanced to assess the horizontal extent of the SD-5 contamination. Location No. 3 may also provide information on the magnitude and vertical extent of the Western Aquafarm plume. Based on the groundwater screening results, it is anticipated that two wells will be installed at both locations. It is planned that one well will be screened within the plume and the second well at each location will be screened below the plume. If contamination is not detected during the groundwater screening program, only one well will be installed at each location. The well will be screened at the interpolated plume depth based on the plume vertical profile as determined by adjacent wells (it is likely that the screen interval will be centered at approximately 20 feet above MSL).
- Based on the results of the first four groundwater screening borings described above, a fifth screening boring (Location No. 5) may be drilled and sampled to



further define the vertical limits of the plume. If this screening boring is conducted, one well will be installed at this location. The well will be installed so that the screen interval is centered in the vertical limits of the plume, if detected or at the interpolated plume depth based on the plume vertical profile as determined by adjacent wells. It is anticipated that the screen interval will be centered at approximately 30 feet msl.

The Execution Plan also proposed a "Pilot Boring Plan" to collect groundwater screening and lithologic data at select extraction and injection well sites wells. The data was proposed to be collected during the installation of these wells. It is now proposed that the data be collected during the preconstruction data collection program. Groundwater screening sampling will be conducted at several extraction wells distributed across the ETR fence area and soil sampling for lithologic characterization (stratigraphic correlation) will be collected at one continuously sampled pilot boring directly south of the ETR fence area. The data will be used to further delineate the extent of the plume and verify soil stratigraphy.

Groundwater samples will be conducted on ten foot intervals above and below the anticipated plume depth and at five foot intervals throughout the anticipated plume depth at the following locations: extraction well EW-3, 100 feet south of extraction well EW-3, extraction well EW-5, extraction well EW-8, and extraction well EW-12. In addition, a continuously sampled pilot boring from ground surface to the top of the confining unit will be completed using the Rotasonic drilling method for lithologic characterization 25 feet south of EW-3.

If groundwater screening results do not agree with the anticipated plume dimensions the need to modify the design (well screen intervals and pumping rates) will be assessed and evaluated in consultation with stakeholders. Any suggested modifications will be submitted for review and approval.



2.5.2 Baseline Sampling

As part of the Preconstruction Data Collection Program a limited baseline groundwater sampling event will be conducted. Select wells will be sampled to verify plume delineation. The selected wells are situated at locations near the toe of the plume, and at the source area. The wells proposed for the baseline sampling are MW-4, MW-20, MW-574, MW-19, and MW-18. These wells in combination with the proposed groundwater screening locations will be used to verify plume delineation prior to installing the SD-5 North ETR system. It should be noted that an additional more comprehensive "baseline" groundwater sampling event will also occur immediately prior to system operation (during the initial phase of system start-up). This sampling event will be discussed in greater detail in the Performance Monitoring Evaluation Plan. If the baseline Preconstruction sampling results do not agree with the anticipated plume dimensions the need to modify the design will be assessed and evaluated in consultation with stakeholders. Any suggested modifications will be submitted for review and approval.

2.5.3 Geotechnical Analysis

A geotechnical analysis will be performed in the area of the proposed SD-5 North Treatment Plant to ensure the soils at the proposed location have an appropriate bearing capacity for the foundations and equipment specified.

2.5.4 Hydraulic Data Collection

The design of the ETR fence has been based in part on slug test data collected in the vicinity of the SD-5 North plume. This information was also used as input to the groundwater flow model. To supplement available hydrogeologic data, an SD-5 North pumping and reinjection test will be conducted beginning in November 1996. The SD-5 North pumping and reinjection test is designed to approximate one extraction and one reinjection well pair of the proposed 14 well



extraction and 14 well reinjection fence. A 72-hour pumping test is planned at one of the extraction well sites on MMR property. A 72-hour reinjection test, at a flow rate approximately twice the design rate (i.e., 60 to 100 gpm) is planned at a reinjection site. Detailed information regarding the proposed SD-5 North pumping and reinjection test will be provided in a SD-5 North Pumping and ReInjection Test Work Plan to be submitted in early November.

If the test results are significantly different than the assumed design values, the need for additional constant rate pumping test(s) will be evaluated. Following analysis of the pumping test data and of the results from the overall preconstruction data collection program, the groundwater model will be revised, if necessary. Reevaluation of the design flow rates and well spacing will be conducted to determine if modifications are necessary. Lithologic and geologic data collected will be reviewed and compared to conditions represented in the resimulation model of SD-5 North. If significant differences exist between the model representation of the aquifer and the results of field data collection, the model will be revised accordingly and an alternative ETR network will be developed through resimulation. Following completion of data collection activities and incorporation of stakeholders comments, Jacobs will present the results of the final groundwater modeling simulations, including recommendations for any design refinements, if required for review and approval by all stakeholders.

2.5.5 Ecological Data Collection

Based on the groundwater modeling performed during evaluation of the SD-5 North ETR system, system operations are not expected to have an impact on Ashumet or Johns Ponds. The proposed location for the SD-5 North reinjection well fence is over 1000 feet north of Ashumet Pond and model results suggest that no measurable groundwater mounding will occur at this distance.



However, to address ecological concerns throughout MMR, ecological sampling has been initiated at Ashumet and Johns Ponds and other ponds, wetlands, and ecologically sensitive areas of the site to obtain baseline data that can be used in assessing the potential impacts of changes in the ambient pond conditions. Efforts to develop facility-wide and SD-5 North specific ecological sampling programs are currently underway. An Ecological TRET meeting was conducted on October 8 and 9, 1996 to establish the conceptual framework (and some specific data collection techniques) for the ecological studies. The scope of the ecological investigation will be presented in the aforementioned sampling program plan.

If required, the SD-5 North ETR network may be adjusted in the future to limit hydraulic impact on Ashumet or Johns Ponds and/or to modify the treatment process to return reinjected water with some of the constituents at concentrations closer to ambient (untreated) conditions. The system will be brought to full scale operation incrementally to allow monitoring any impact on Ashumet or Johns Ponds.

2.5.6 Data Collection During Construction

Following the Preconstruction Data Collection Program (and system refinement, if required based on the data discussed above) a step-drawdown test will be conducted at two extraction well locations (EW-3, EW-17, and EW-25) and step-drawdown and step-injection tests will be conducted at two injection well locations (IRW-6, IRW-14 and IRW-26) to assess specific capacity, well performance and provide verification of presumed aquifer hydraulic conductivity.

2.6 REGULATORY REQUIREMENTS

2.6.1 Introduction

This section identifies and discusses federal, state, and local environmental applicable or relevant and appropriate requirements (ARARs) for the MMR SD-5



plume response project, plus discusses other regulatory requirements such as compliance with the Record of Decisions (ROD) or recommendations from the Technical Review and Evaluation Team (TRET).

2.6.2 Applicable Or Relevant And Appropriate Requirements (ARARS)

Project Scope

The project includes the installation of groundwater extraction wells, the installation of collection systems for the extracted groundwater, the installation of groundwater treatment systems, the installation of treated water distribution systems, the installation of groundwater reinjection wells, and the installation of groundwater monitoring wells. The project also includes operation and maintenance of the extraction, treatment, and reinjection system. The following elements of the project work were considered in determining the appropriate ARARs:

- Construction of decontamination facilities.
- The placement of support facilities.
- Access road improvement.
- Tree clearing, grubbing, and topsoil stripping.
- Extraction, monitoring well, and reinjection well installation and operation.
- Air emissions.
- Residuals management.
- Potable water supplies to the treatment units.
- Septic Systems.

The Federal and State ARARs pertinent to these elements are summarized in Table 2-2.

Federal ARARs

The following federal environmental statutes have been identified as potential ARARs for the installation and operation of the SD-5 plume response project:

- Clean Air Act (CAA)
- Clean Water Act (CWA)
- Safe Drinking Water Act (SDWA)
- Resource Conservation and Recovery Act (RCRA)

The following sections discuss these regulations and their pertinence to the SD-5 project.

Clean Air Act

The objective of the CAA is to protect and enhance the quality of the nation's air resources in order to promote and maintain public health and welfare and the nation's production capacity. The programs within the CAA that contain potential ARARs for the SD-5 project are the National Ambient Air Quality Standards (NAAQS) for Criteria Pollutants, and the National Emission Standards for Hazardous Air Pollutants (NESHAP).

NAAQS for six pollutants (carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides) appear in the Code of Federal Regulations (CFR) in 40 CFR 50. These standards are based on the direct health effects of these pollutants to sensitive groups, with no consideration to economic factors. The NAAQS take all sources of a given pollutant into account and establish ceilings that are not to be exceeded in the United States. The only SD-5 Plume Response project activities that could impact NAAQS is volatile organic carbon emissions (VOCs) that can contribute to ozone formation. The ceiling for ozone is relevant and appropriate to these activities.

In general, new sources of air emissions must undergo a preconstruction review. Preconstruction reviews are conducted to determine whether a new source will interfere with attainment or maintenance of NAAQS. The permitting process associated with attainment of NAAQS applies only to major sources of air emissions. The SD-5 plume containment project will not be a major source of air emissions, and the concentration of VOCs in the groundwater plumes are very low (micrograms/liter range). However, compliance with NAAQs is an ARAR for the plume containment projects.

A number of compounds have been detected in the SD-5 groundwater plume that are included in the list of hazardous air pollutants (HAPs). In addition, benzene was detected in the plume, which is on the list of NESHAP compounds. In general, the NESHAP regulations give emission limits for hazardous air pollutants and mandate testing, monitoring, and reporting requirements. The HAP and NESHAP compounds are only present in the groundwater plumes in low, (micrograms/liter) concentrations and are not expected to generate significant air emissions. However, meeting the requirements of NESHAPs is an ARAR for the plume containment projects.

Clean Water Act

The primary purpose of the CWA, also known as the Federal Water Pollution Control Act, is to restore and maintain the quality of surface waters.

The CWA is applicable to the disposal of liquid residuals. The contaminated groundwater will be extracted, treated, and reinjected. Since reinjected groundwater can potentially reach surface waters, the requirements of the CWA will be ARARs. The CWA may impose limitations, standards and permit conditions. The CWA will also impose standards for stormwater runoff during construction and from the treatment systems.

Safe Drinking Water Act

The purpose of the SDWA is to protect and maintain United States drinking water resources. This regulation is an ARAR for the reinjection of treated groundwater and for the handling of treatment area residuals, such as backwash from the removal of suspended solids and iron. The SDWA specifies maximum contaminant levels (MCLs) and MCL goals for inorganic and organic chemicals and microbiological contaminants.

Resource Conservation and Recovery Act

RCRA is applicable to the solid treatment residuals. Solid treatment residuals include: drill cuttings from the installation of wells, spent activated carbon, and sludges from the removal of suspended solids and iron. The drill cuttings and sludges are expected to pass the Toxicity Characteristic Leaching Procedure (TCLP) and are not expected to require handling and disposal as a hazardous waste. The activated carbon may not pass the TCLP test and may need to be handled and regenerated as a hazardous waste.

State ARARs (Commonwealth Of Massachusetts)

The Commonwealth of Massachusetts ARARs identified as pertinent to the SD-5 plume response project include:

- 302 CMR 6: Adopting Inland Wetland Orders
- 310 CMR 6: Ambient Air Quality Standards for the Commonwealth of Massachusetts
- 310 CMR 7: Air Pollution Control
- 310 CMR 15: The State Environmental Code, Title 5, Standard Requirements for the Siting, Construction, Inspection, Upgrade and Expansion of On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage.



- 310 CMR 19: Solid Waste Management
- 310 CMR 22: Drinking Water Regulations
- 310 CMR 27: Underground Water Source Protection
- 310 CMR 30: Hazardous Waste
- 310 CMR 40: Massachusetts Contingency Plan
- 314 CMR 2: Permit Procedures
- 314 CMR 5: Groundwater Discharge Permit Program
- 314 CMR 6: Groundwater Quality Standards
- 314 CMR 8: Supplemental Requirements for Hazardous Waste Management Facilities
- 314 CMR 12: Operation and Maintenance and Pretreatment Standards for Wastewater Treatment
- 314 CMR 15: The Prevention and Control of Oil Pollution in the Waters of the Commonwealth

302 CMR 6: Adopting Inland Wetland Orders

The intent of this regulation is to “preserve and promote the public safety, private property, wildlife, fisheries, water resources, flood plain areas and agriculture, and to prevent damage to the environment”. These goals are to be accomplished by imposing restrictions on the inland wetlands and flood plain areas.

If any of the activities associated with the SD-5 plume response project impact wetlands or flood plains, which is not anticipated, then this section will become an ARAR.

310 CMR 6: Ambient Air Quality Standards for the Commonwealth of Massachusetts

This chapter sets ambient air quality standards for: sulfur dioxide, particulates, carbon monoxide, ozone, nitrogen oxides, and lead. Note: These regulations are essentially the same as the federal regulations included as part of the Clean Air Act.

310 CMR 7: Air Pollution Control

Section 7.02 defines the types of facilities which are required to file Environmental Notification Forms (ENF). No substantial construction or reconstruction is allowed unless any required ENF is filed and approved. Exemptions to this requirement are listed in subsection (4)(a). The SD-5 plume response project is probably excepted by subsection (4)(a)8, emission less than one ton/year.

Section 7.03 provides additional exemptions to the permitting requirements. Subsection (14) provides an exemption for groundwater remediation and soil venting projects, as long as treatment systems are provided that achieve at least a 95% reduction in VOC emissions. The groundwater concentrations are very low so significant air emissions are unlikely. However if air emissions become significant the 95% reduction requirement may become an ARAR. An additional exemption is provided by 314 CMR 0049 which allows for a waiver from the 95% control requirement if it can be demonstrated that the air emission will present no significant risk to public health.

Section 7.18 provides additional restrictions for emissions from volatile or halogenated organic compounds. However, this section is not applicable because it is restricted to specific, listed processes. None of the processes listed include groundwater remediation projects.



310 CMR 15: The State Environmental Code, Title 5: Standard Requirements for the Siting, Construction, Inspection, Upgrade and Expansion of On-site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage

Section 15.003 specifies that a construction permit is required for installation of any septage system, except for systems operated by an agency of the Commonwealth or of the Federal Government.

Section 15.260 provides design information for "Tight Tanks", if used.

310 CMR 19: Solid Waste Management

This chapter provides the requirements for solid waste facilities. This chapter is not applicable for the SD-5 plume response project.

310 CMR 22: Drinking Water Regulations

Chapters 22.05 through 22.11 list the maximum allowable concentrations of contaminants in drinking water and requires that certified labs be used to conduct the sample analysis.

310 CMR 27: Underground Water Source Protection

Section 27.03 lists the Classes of reinjection wells. The reinjection wells used as part of the SD-5 plume response project will be Class V wells, wells not included as types I through IV.

Section 27.04 lists that Class V wells are not allowed if they will move pollutants to underground drinking water supplies.

310 CMR 30: Hazardous Waste

Section 30.102 lists the methods for the identification of hazardous waste.

Section 30.104 lists wastes that are exempt from the hazardous waste regulations. Samples collected for testing are exempt from the regulations.



specifications are met, requires correction of any problems that are discovered, and requires documentation of compliance.

314 CMR 2: Permit Procedures

Section 2.01 states that discharges to groundwater be permitted per Section 2.05.

Section 2.03 lists the required permit forms for discharges to groundwater.

Section 2.05 lists the contents of a "Fact Sheet" used as a basis for the permit.

314 CMR 5: Groundwater Discharge Permit Program

Section 5.03 states that anyone who discharges onto or below the land surface is required to file a permit application. The requirements of this permit application will be an ARAR for the SD-5 plume response project.

Section 5.04 states that the groundwater discharge permit include any stormwater that has come into contact with process wastes. The contact between stormwater and the process wastes will not occur as part of these projects, but demonstration that no contact will occur can be a project ARAR.

Section 5.10 lists effluent concentration limitations. Maximum concentrations are set for a number of contaminants which may be present in the extracted groundwater including: lead, iron, manganese, total dissolved solids, pH, nitrate, and total nitrogen. In addition, the concentration of any toxins must meet "Health Advisory Levels".

Section 5.19 lists the following requirements for discharge to the groundwater:

- No discharge can result in a violation of surface water or groundwater quality standards.
- The discharge must meet the requirements of 40CFR307(a)
- Bypass of the treatment system is prohibited.



discharged within 200 feet of "Outstanding Resource" water is not allowed unless the discharged water meets groundwater quality standards and that a permit is required for discharge to the groundwater. Meeting the requirements for a groundwater permit will be an ARAR for the SD-5 plume response project.

Section 40.0045 lists the following requirements for the discharge of remediation effluent to the groundwater:

- The discharge must not impair the quality of the groundwater - the discharge must meet the concentration requirements listed in 314 CMR 6.0.
- The discharge must not create groundwater mounding within two feet of the surface.
- The discharge must not result in flooding or breakout to the ground surface.
- The discharge must not exacerbate existing conditions or impair the remediation of existing conditions.

Section 40.0049 states that air emissions from remediation activities can be exempted from the 95% control requirement if it is demonstrated that the emissions presents no significant risk to public health.

Sections 40.0855 and 40.0857 discuss the identification of remedial alternates and the evaluation of those alternates. These sections state that a detailed evaluation of alternates is not required as long as the selected alternate results in destruction or detoxification of the material, can be implemented without a significant risk or harm to the health, safety, public welfare, or the environment.

Section 40.0874 lists the contents of a Remedial Implementation Plan (RIP). The intent of this plan is being satisfied by submittal of this document.

Section 40.0890 lists requirements for operation and maintenance of the remedial action. This section requires monitoring to make sure the remediation



specifications are met, requires correction of any problems that are discovered, and requires documentation of compliance.

314 CMR 2: Permit Procedures

Section 2.01 states that discharges to groundwater be permitted per Section 2.05.

Section 2.03 lists the required permit forms for discharges to groundwater.

Section 2.05 lists the contents of a "Fact Sheet" used as a basis for the permit.

314 CMR 5: Groundwater Discharge Permit Program

Section 5.03 states that anyone who discharges onto or below the land surface is required to file a permit application. The requirements of this permit application will be an ARAR for the SD-5 plume response project.

Section 5.04 states that the groundwater discharge permit include any stormwater that has come into contact with process wastes. The contact between stormwater and the process wastes will not occur as part of these projects, but demonstration that no contact will occur can be a project ARAR.

Section 5.10 lists effluent concentration limitations. Maximum concentrations are set for a number of contaminants which may be present in the extracted groundwater including: lead, iron, manganese, total dissolved solids, pH, nitrate, and total nitrogen. In addition, the concentration of any toxins must meet "Health Advisory Levels".

Section 5.19 lists the following requirements for discharge to the groundwater:

- No discharge can result in a violation of surface water or groundwater quality standards.
- The discharge must meet the requirements of 40CFR307(a)
- Bypass of the treatment system is prohibited.



Section 5.26 contains a form for applying for a permit to discharge industrial waste to the groundwater.

314 CMR 6: Groundwater Quality Standards

Section 6.06 lists minimum groundwater quality standards.

Section 6.07 states that no discharge will occur to the groundwater without a permit.

314 CMR 8: Supplemental Requirements for Hazardous Waste Management Facilities

Section 8.01 states that wastewater treatment units which treat, store, or dispose of hazardous waste generated at the site must comply with 310 CMR 30. The spent carbon generated at the SD-5 treatment system may be a hazardous waste based on the EP Toxicity criteria.

314 CMR 12: Operation and Maintenance and Pretreatment Standards for Wastewater Treatment

Section 12.03 states that any bypass around a wastewater treatment system must be cap sealed closed.

Section 12.04 states that the system must be maintained to assure that the system meets the effluent requirements.

314 CMR 15: The Prevention and Control of Oil Pollution in the Waters of the Commonwealth

It is not anticipated that any oils will be used or stored at the site. However, if any oils are used, this section could be an ARAR for the SD-5 plume response project.



pumps operating. The extraction and reinjection piping headers can be expanded to 1000 gpm through the installation of larger pumps. Higher rates can be handled by installing parallel headers.

- SD-5 North Treatment Plant. The SD-5 North Treatment Plant is capable of operating at flow rates up to 675 gpm range with no modifications to the system. By adding additional treatment components, the acceptable system flow rate could be increased to 1640 gpm.

Currently, it is not anticipated that it will be necessary to operate the SD-5 North ETR system at flow rates greater than 450 gpm.

2.8.2 Site Access

A large portion of the proposed reinjection well fence is currently located on private property. At the present time real estate access for the portions of the proposed reinjection well fence located on private property has not been obtained. Proposed refinements to the SD-5 North design, if required, must consider potential access limitations.

2.8.3 Hydraulic Monitoring

The Draft Performance Monitoring Plan for the SD-5 North ETR system will be submitted for review in December 1996. Details regarding performance monitoring for the SD-5 North system will be included in this draft submittal. However, based on a preliminary analysis of potential aquifer drawdown and mounding produced by the SD-5 North ETR well network it is apparent that traditional hydraulic monitoring to demonstrate capture using observation wells may have limited value. This potential operational difficulty is due to low pumping rates to meet the design objective of minimizing impact to Ashumet and Johns Ponds and the surrounding ecological system at SD-5 North. This design limitation will increase the complexity and cost of performance monitoring at the site and potentially decrease the accuracy of performance monitoring. In general,

TABLE 2-2

ARARS WITH SUBSTANTIVE REQUIREMENTS

LAWS	RULES & REGULATIONS	DESCRIPTION	AFFECTED PORTION OF REMEDY	SUBSTANTIVE REQUIREMENTS
Solid Waste Disposal Act (SWDA) as amended by Resource Conservation and Recovery Act (RCRA) of 1976 [42 U.S.C. 6901]				
40 CFR 261 - Identification and Listing of Hazardous Wastes	40 CFR 261.1-7, 10, 11, 20-24, 30-33	Definition of Solid and Hazardous Wastes	Solid Residuals Management	Solid treatment residuals will require testing by the toxicity characteristic leaching procedure to determine if they are hazardous.
40 CFR 268 - Land Disposal Restrictions	40 CFR 268.30-37	Waste Specific Prohibitions	Solid and Liquid Residuals Management	No liquid wastes will be disposed of on land. If any of the waste codes listed in these sections are found, they will not be disposed of on land.
	40 CFR 268.40-43	Treatment Standards	Solid and Liquid Residuals Management	If wastes subject to 40 CFR 268.30-37 are found, treatment as specified in these sections will be applied.
	40 CFR 268-45	Treatment Standards for Hazardous Debris	Solid Residuals Management	If debris is found to be hazardous, it will be treated such that it is no longer contaminated with hazardous waste.
40 CFR 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264.351	Closure	Treatment System	All waste and residue must be removed from site at closure.
Clean Water Act (CWA) of 1977, as amended [33 U.S.C. 1251]				
40 CFR 122 - The National Pollutant Discharge Elimination System (NPDES)	40 CFR 122.1-7	Definitions and General Program Requirements	Liquid Residuals Management	Discusses purpose and scope, definitions, exclusions from NPDES permitting, prohibitions, permits, continuation of expiring permits, and confidentiality.

TABLE 2-2

ARARS WITH SUBSTANTIVE REQUIREMENTS

LAWS	RULES & REGULATIONS	DESCRIPTION	AFFECTED PORTION OF REMEDY	SUBSTANTIVE REQUIREMENTS
40 CFR 122 - The National Pollutant Discharge Elimination System (NPDES) (cont.)	40 CFR 122.21, 22, 28, 29	Permit Application and Special NPDES Program Requirements	Liquid Residuals Management	Specifies scope and details of NPDES permit applications.
	40 CFR 122.41-48	Permit Conditions	Liquid Residuals Management	Establishes limitations, standards, and other permit conditions applicable to all permits, including calculation of standards, permit duration, and compliance schedules. Specifies requirements for recording and reporting of monitoring results.
	40 CFR 122.49	Considerations Under Federal Law	Liquid Residuals Management	When applicable, the Wild and Scenic Rivers Act, National Historic Preservation Act, Endangered Species Act, Coastal Zone Management Act, Fish and Wildlife Coordination Act, and any executive orders will be complied with.
40 CFR 125 - Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR 125.1-3	Criteria and Standards for Imposing Technology-Based Treatment Requirements	Liquid Residuals Management	Establishes purpose, scope, definitions and criteria for determining standards for technology-based requirements.
	40 CFR 125.30-32	Criteria and Standards for Determining Fundamentally Different Factors	Liquid Residuals Management	Describes criteria and standards for establishing whether effluent limitations differing from CWA national limits should be imposed. These may be established if factors relating to the discharge are fundamentally different from those considered in promulgating national limits.
	40 CFR 125.100-104	Criteria and Standards for Best Management Practices	Liquid Residuals Management	Best management practices (BMPs) shall be specified to establish specific objectives for control of toxic and hazardous pollutants. BMPs may reflect requirements for spill prevention control and countermeasure plans.

TABLE 2-2

ARARS WITH SUBSTANTIVE REQUIREMENTS

LAWS	RULES & REGULATIONS	DESCRIPTION	AFFECTED PORTION OF REMEDY	SUBSTANTIVE REQUIREMENTS
40 CFR 136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants	40 CFR 136.1-5, Appendices A-C	Analytical Procedures for NPDES Applications and Reports	Liquid Residuals Management	Specific methods will be used.
40 CFR 403 - General Pretreatment Regulations for Existing and New Sources of Pollution	40 CFR 403.1-7	Purpose, applicability, objectives, definitions, prohibited discharges, categorical standards, and removal credits.	Liquid Residuals Management	Pretreatment standards as promulgated by a POTW will be adhered to, if a discharge to POTW occurs. If fundamentally different factors (as defined in 40 CFR 125.30-32) exist, a variance will be prepared.
Public Health Service Act: Title XIV, as amended by the Safe Drinking Water Act of 1988 [42 U.S.C. 300 (f)]				
40 CFR 141 - National Primary Drinking Water Regulations	40 CFR 141.11, 12, 50, 51	Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)	Liquid Residuals Management	MCLs and MCLGs for organic and inorganic chemicals may be required to be met if wastewater may reach drinking water sources.
	40 CFR 141.60-63	Revised Primary Drinking Water Regulations	Liquid Residuals Management	Revised MCLs and MCLGs for organic and inorganic chemicals sets best available technology for some organics. If these organics are found in wastewater that may reach drinking water sources, BAT will be applied.
40 CFR 143 - National Secondary Drinking Water Regulations	40 CFR 143.3	Secondary MCLs	Liquid Residuals Management	Secondary MCLs, which affect mostly aesthetic qualities of drinking water, may be required to be met if wastewater may reach drinking water sources.

2.7 BASIS FOR DESIGN

The SD-5 ETR system has a number of objectives which include (Strategic Plan AFCEE, 1996):

- Design, construct, and operate a full-scale ETR system.
- Contain, capture, and remediate the SD-5 plume.
- Minimize adverse impacts on Ashumet and Johns Pond and their surrounding environments.
- Monitor performance of treatment system.
- Minimize disturbances by the remedial system on the Western Aquafarm, Ashumet Valley and CS-120 East plumes. (This objective may not be achieved for a portion of the Western Aquafarm plume, due to its proximity to the SD-5 plume and containment system.)
- Minimize disturbance to private property.
- Monitor groundwater quality to assess performance and assist future design at other sites.

2.7.1 Extracted Water Concentrations

The MMR "Plume Containment System 60% Design", issued January 1996, (OpTech, 1996a) included a list of contaminants in the SD-5 plume that were used as a basis for preparation of the design. Since that time, the design basis for location of the extraction wells has been changed from the toe of SD-5 South plume to the toe of the SD-5 North plume. Since the location of the extraction well fence have been changed, the design basis concentrations have changed.



“60% Design” Concentrations

The extraction well location basis for the OpTech “60% design” was to locate all the extraction wells in the toe of the plume. Because all the water would be extracted from the toe, initial concentrations of contaminants would be very low but would increase with time as the higher concentration portions of the plume move toward the toe. To allow for the future increase in concentrations, the system was designed to handle the average concentration in the plume, with a margin for safety.

Design Concentrations

Because the extraction wells are now closer to the concentrated part of the plume, a revised approach was used to recalculate the extracted water concentrations:

- A “Weighted Average” concentration was calculated using information from the monitoring wells that are located in the vicinity of the extraction wells. This average concentration was used for economic evaluations and for preparation of the material balance on the Process Flow Diagram (PFD).
Note: The concentrations determined using this approach are believed to be conservatively high because they do not allow for clean water that will be drawn into the top and bottom of the plume.
- The concentrations in the most concentrated part of the plume were also calculated. These concentrations were used as a basis to size the equipment. For SD-5, multiple areas were considered because of the presence of the Western Aquafarm and PFSA plumes. The following table includes the highest concentration of contaminants, upgradient of the extraction well fence, in each of the plumes.

The following summarizes the concentrations determined for both the weighted average case and the hot spot case. The table also compares these concentrations with the concentrations included in the “60% design”.



Concentration. micrograms/liter (ug/l)

<u>Contaminant</u>	<u>PFD Basis</u>	<u>Equip Size Basis</u>	<u>"60% Design"</u>
Benzene	-	4.5	0.78
Toluene	0.8	6.61	-
Ethylbenzene	2	37.5	-
Xylene	4	124	-
1,2-DCE	BQL	1.2	-
Methylene chloride	BQL	6	0.35
1,1,1 - TCE	BQL	61	3.8
1.1.2 - TCE	BQL	0.9	-
1,2-Dibromoethane (EDB)	BQL	0.02	1.1
1,1,1,2-Tetrachloroethane	1.14	1.7	-
1,1,2,2-Tetrachloroethane	BQL	0.74	-
PCE	BQL	BQL	0.77
Bis (2-Ethylhexyl) Phthalate	BQL	20	-
Iron	243	-	243
Manganese	44	-	44
Lead	-	No Data	4.2
TSS	2,500	2,500	12,000

A more complete discussion of individual contaminants is as follows:

- TSS (total suspended solids): The 2500 $\mu\text{g/l}$ design basis is based on the maximum practical capacity of the Greensand filters, and based on



information from other wells in the area such as the CS-4 plume containment wells and the Coonamessett Well is considered to be conservative. The concentrations listed in the Data Gap were not considered as representative of the TSS that would be expected in a full scale extraction system. The previous TSS data was collected from monitoring wells with no sand pack (the underground formation was allowed to collapse around the screen). The extraction wells will have fully developed sand packs and will be operated long enough to remove fines from the area around the screen. This design basis concentration will be confirmed by sampling during pumping tests that are scheduled to be conducted at the site.

- Only limited data is available on iron and manganese concentrations. Additional sampling is being conducted to confirm the design basis.
- Methylene chloride is listed in samples collected upgradient from the extraction fence, but is not believed to be present. Methylene chloride is a common laboratory reagent and is listed on the laboratory reports as most likely being the result of laboratory contamination.
- Additional information is being collected on the concentrations of lead in the SD-5 plume.
- JP-4 fuel contains high concentrations of organic compounds with a higher molecular weight than benzene, such as: ethylbenzene, toluene, xylenes, naphthalenes, etc. However, a review of the laboratory data indicates that these higher molecular weight compounds are not present in the plume in high concentrations.

2.7.2 Effluent Design Basis (Treated Effluent)

Effluent treatment levels will normally be based on non-detection of chemicals by U.S. EPA analytical methods Drinking Water 504 and 502. Method 504 (EDB only) has interference with chlorinated hydrocarbons. The results can give false



positive readings. If a "hit" occurs, Method 524 will be used. These analytical methods are gas chromatography or mass spectrometer methods. The analysis for metals will be conducted by Solid Waste Method. Treatment will be conducted to reduce the concentrations of the contaminants to those shown in Table 2-3. The meeting of such goals does not create any technical difficulty for the treatment units as they are designed.

Strictly interpreted, the detection limit (DL) is the lowest amount of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. A chemical present below that level cannot reliably be distinguished from noise. DLs are chemical-specific and instrument-specific and are determined by statistical treatment of multiple analyses in which the ratio of the lowest amount observed to the electronic noise level (i.e., the signal-to-noise ratio) is determined. On any given day, in any given sample, the calculated limit may not be attainable; however, a properly calculated limit can be used as an overall general measure of laboratory performance.

Two (2) types of DLs may be described; 1) instrument DLs (IDLs) and 2) method DLs (MDLs). The IDL is generally the lowest amount of a substance that can be detected by an instrument; it is a measure only of the DL for the instrument, and does not consider any effects that sample matrix, handling, and preparation may have. The MDL, on the other hand, takes into account the reagents, sample matrix, and preparation steps applied to a sample in specific analytical methods.

Due to the irregular nature of instrument or method noise, reproducible quantitation of a chemical is not possible at the DL. Generally, a factor of three to five is applied to the DL to obtain a practical quantitation limit (PQL), which is considered to be the lowest level at which a chemical may be accurately and reproducibly quantitated. This is the value used by Jacobs Engineering. DLs

indicate the level at which a small amount would be "seen", whereas PQLs indicate the levels at which measurements can be "trusted". The CRQL is the chemical-specific level that a CLP laboratory must be able to routinely and reliably detect and quantitate in specific sample matrices, and may or may not be equal to the reported quantitation limit of a chemical. CRQL are updated each year by U.S. EPA.



TABLE 2-3

Cleanup Levels - Treated Effluent

Hazardous Substance	CAS No. ¹	Method ²	PQL ³	CRQL ⁴	MCL ⁵	Cleanup Level ⁶
EDB	106-93-4	DW 504	0.02 µg/l	-	5 µg/l	0.02 µg/l
1,2-DCE	107-06-2	DW 502	0.07 µg/l	5 µg/l	5 µg/l	0.07 µg/l
Benzene	71-43-2	DW 502	0.1 µg/l	5 µg/l	5 µg/l	0.1 µg/l
Ethyl benzene	100-41-4	DW 502	0.2 µg/l	10 µg/l	700 µg/l	0.2 µg/l
Iron	1543-83-10	SW 6010A	0.07 mg/l	100 µg/l	300 µg/l	300 µg/l
Manganese	7439-96-5	SW 6010A	0.02 mg/l	15 µg/l	50 µg/l	50 µg/l
PCE	127-18-4	DW 502	0.3 µg/l	5 µg/l	5 µg/l	0.3 µg/l
Toluene	108-88-3	DW 502	0.2 µg/l	10 µg/l	1,000 µg/l	0.2 µg/l
1,1,1 - TCE	79-01-6	DW 502	0.03 µg/l	5 µg/l	5 µg/l	0.03 µg/l
Xylene	1330-20-7	DW 502	0.5 µg/l	10 µg/l	10,000 µg/l	0.5 µg/l
1,1,2 - TCE	79-00-5	DW502	1.0 µg/l	5 µg/l	5 µg/l	1.0 µg/l
Lead	7439-92-1	SW6010A	0.5 µg/l	3 µg/l	15 µg/l ⁷	15 µg/l
Methylene Chloride	75-09-2	DW502	0.3 µg/l	5 µg/l	N/A	N/A
1,1,1,2 -Tetra-chloroethane	630-20-6	DW502	0.5 µg/l	5 µg/l	L	0.5 µg/l
1,1,2,2 -Tetra-chloroethane	79-34-5	DW502	0.4 µg/l	5 µg/l	L	0.4 µg/l
Bis (2-Ethylhexyl) phthalate	117-81-7	DW524	10.0 µg/l	10.0 µg/l	N/A	10.0 µg/l

1. Chemical Abstracts Service registry number, this number is unique for each chemical and allows for efficient searching.
2. The U.S. EPA analytical method. The U.S. EPA provides analytical procedures to test solid wastes and drinking water.
3. Practical Quantification Limit as determined by the U.S. EPA. This is the lowest level at which a chemical can be accurately and reproducibly quantitated. Usually equal to the instrument detection limit multiplied by a factor of three to five, but varies for different chemicals and different samples. Ref. Quality Assurance Project Plan, HQ AFCEE Ver. 1.1, Feb. 1996.
4. The U.S. EPA Contract - Required Quantitation Limit Chemical-specific levels that a CLP laboratory must be able to routinely and reliably detect and quantitate in specified samples.
5. The Maximum Contaminant Level (MCL) specified under Section 141 of the Federal Safe Drinking Water Act.
6. Cleanup Level is set either at the Practical Quantitation Limit (PQL) or at the MCL, which ever is most applicable..
7. EPA Action Level. No MCL has been promulgated.

L Listed for promulgation
 NA None Applicable



Jacobs Engineering Group Inc.

SD-5 North Draft Design Report

2.8 DESIGN BASIS LIMITATIONS

As discussed previously, the design objectives for the SD-5 North ETR system are in some cases conflicting. Therefore, to design a groundwater containment system for the SD-5 North plume requires a balancing of design objectives to the degree possible, while attempting to satisfy the concerns of all stakeholders. To compensate for potential uncertainties, the SD-5 North ETR system design incorporates considerable flexibility in acceptable system flow rates and water quality. However, it is important to understand the limitations of the SD-5 North system design to provide a framework for project expectations.

2.8.1 Physical Capacity of SD-5 North ETR System

The SD-5 North ETR system has been designed to operate at a system flow rate of approximately 450 gpm and a minimum system flow rate of approximately 175 gpm. These flow rates are approximately 26 percent higher and 50 percent lower than the expected operating flow rate of 355 gpm. Individually, subsets of the SD-5 North ETR system have the following operating limitations:

- **Extraction and ReInjection Wells.** The transmissivity of aquifer sediments at SD-5 North will support groundwater extraction/reinjection rates more than 10 times higher than recommended extraction/reinjection rates for the SD-5 North ETR system. Therefore, the primary limitation on groundwater extraction/ reinjection rates for SD-5 North will be the size of pumps selected for the extraction wells and the capacity of system piping and treatment plant processes. The extraction/reinjection well fences will be controlled by valves that can be adjusted separately at each extraction/reinjection well location to increase system flexibility.
- **System Piping.** The SD-5 North ETR system piping is capable of operating at flow rates up to 560 gpm range with no modifications to the system. Flow rates up to 1000 gpm are possible in the treatment system with both feed

pumps operating. The extraction and reinjection piping headers can be expanded to 1000 gpm through the installation of larger pumps. Higher rates can be handled by installing parallel headers.

- SD-5 North Treatment Plant. The SD-5 North Treatment Plant is capable of operating at flow rates up to 675 gpm range with no modifications to the system. By adding additional treatment components, the acceptable system flow rate could be increased to 1640 gpm.

Currently, it is not anticipated that it will be necessary to operate the SD-5 North ETR system at flow rates greater than 450 gpm.

2.8.2 Site Access

A large portion of the proposed reinjection well fence is currently located on private property. At the present time real estate access for the portions of the proposed reinjection well fence located on private property has not been obtained. Proposed refinements to the SD-5 North design, if required, must consider potential access limitations.

2.8.3 Hydraulic Monitoring

The Draft Performance Monitoring Plan for the SD-5 North ETR system will be submitted for review in December 1996. Details regarding performance monitoring for the SD-5 North system will be included in this draft submittal. However, based on a preliminary analysis of potential aquifer drawdown and mounding produced by the SD-5 North ETR well network it is apparent that traditional hydraulic monitoring to demonstrate capture using observation wells may have limited value. This potential operational difficulty is due to low pumping rates to meet the design objective of minimizing impact to Ashumet and Johns Ponds and the surrounding ecological system at SD-5 North. This design limitation will increase the complexity and cost of performance monitoring at the site and potentially decrease the accuracy of performance monitoring. In general,



groundwater extraction systems are designed to operate at pumping rates that exceed seasonal fluctuations to ensure plume capture can be easily achieved and demonstrated. For the SD-5 North plume, seasonal fluctuations will be much greater than the influence of the SD-5 North system. In addition, at distances greater than 50 feet from extraction and reinjection well fences it is unlikely that groundwater elevation changes due to operation of the SD-5 North system can be accurately measured. It is important that all stakeholders recognize this design limitation since it may directly affect the defensibility of performance monitoring for the SD-5 North plume.

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3.0 DESCRIPTION OF TREATMENT PROCESS

The treatment process will consist of:

- Extraction wells
- Collection piping and an influent tank
- pH control
- Greensand filters to remove suspended solids, iron, and manganese.
- Solids settling and collection facilities
- An activated carbon system to complete the removal of the toxic organics to below the detection limit
- An effluent tank
- Reinjection wells

Process Flow Diagrams (PFD's) and Process and Instrument Diagrams (P&ID's) showing the treatment system are included in Volume II.

The following is a brief description of the process. For a more complete description, see Section 4.0.

3.1 PROCESS DESCRIPTION

3.1.1 Extraction Wells

There will be 14 extraction wells (2EWP-101-1-14) supplying contaminated groundwater from the SD-5 plume to the Treatment Unit 1. The 14 well pumps (2RW-101-1-14) will be controlled from a central location. The well pumps supply, through a double walled pipe header, the contaminated water to the treatment unit.

The double wall pipe providing secondary containment for the influent water will have leak detection along the header to ensure against leakage of the contaminated water along the supply route.



tank (1T-102) via the backwash pumps (1-P-103 A/B). The backwash water will go to the sedimentation tank (1T-103). Backwash will continue 15 to 20 minutes at 1140 gpm. The flow will then return to normal.

The backwash water will go to the sedimentation tank (1T-103). The backwash will be a very thin slurry with some 30 pounds of solids in the 15,000 to 17,000 gallons of water. The slurry will be allowed to settle for 2 - 3 hours. After 3 hours, the solids will have settled having a 3% solids slurry at the tank bottom. The top 17,000 gallons will be pumped back to the influent tank for re-treatment.

Between backwashes, the processing rate will be sufficient to pull 1T-101 down to a level that can receive the 17,000 gallons of the next backwash. The sedimentation tank will receive about 80 gallons of 3% solids per day from the backwashes of two (2) Greensand filter per day. The solids will accumulate in 1T-103 until a load of 2,000-3,000 gallons is available to load out a 3,000 gallon truck. The tank truck will be connected by hose to the slurry pump (1P-104) and the truck loaded from the bottom of the tank cone. Because of the possible solids handling problems when handling a slurry, the truck loading, the slurry pump and the sedimentation tank will have facilities for flushing and air blowing the lines. Secondary containment is also provided to collect any potential spills from the loading operation. The truck loading will be a manual operation. The backwashing and decanting are automated and do not require operator supervision.

There will be a flow control valve on the discharge of the recirculation pumps (1-P 105A/B) which pump the decanted liquor from the sedimentation tank back to the influent tank (1T-101). The backwash and the decantation pumping are automated. The flow control will permit adjustment of the pumping rate to allow

coordination with the normal operation of the influent tank and to prevent overfilling.

3.1.4 Carbon Adsorption

The carbon adsorption system consists of two trains of two adsorbers each. The two adsorbers in each train operate in series. The adsorber with the freshest carbon will be the second unit in the series and serves as a backup filter. The valving arrangement with each train allows the necessary flexibility to accomplish the various tasks of emptying, filling, forward and reverse series flow, single unit flow and parallel flow. The two trains operate in parallel.

Carbon, which will be delivered in hopper bottom trailers with 20,000 pound loads, are an adsorber refill. When the carbon in the lead adsorber in a train is spent, the carbon will be exchanged for fresh carbon.

Two trailers will be required for a carbon exchange. An empty trailer arrives first to receive the spent carbon from the spent adsorber. The carbon fill line on the empty trailer will be connected by a hose to the spent carbon line at the trailer service area. The spent carbon adsorber will be isolated from the production stream and the full stream of the train flows through the other adsorber which has been the backup filter. The spent carbon adsorber will be pressurized to 30 psig. The empty truck vents are opened and the pressurized adsorber opened allowing the spent carbon to flow to the empty truck. The 4,000 gallons of water and the spent carbon of the adsorber are now in the trailer. The trailer water unloading line will be connected by hose to the backwash water line at the trailer station. The 15 psig air line will be connected to the trailer and the water blown to Tank 101. Secondary containment is provided around the carbon loading spot to collect any potential spills.

The spent carbon loaded trailer will be returned to a licensed firm for reactivation. The fresh carbon trailer will be located at the trailer station and connected by hose to the fresh carbon line. The empty adsorber will be filled with water and pressurized to 15 psig. Half of the water in the adsorber will be transferred to the trailer. This will leave water in the adsorber to serve as a cushion to protect the bottom distributor plate from shock when the fresh carbon is transferred.

The trailer will be pressurized and the fresh carbon and water will be transferred to the adsorber. The trailer will be disconnected. The adsorber will be backwashed to remove the fines and characterize the fresh carbon bed. The backwash takes about 15 minutes with 1,000 gpm flow. The fresh adsorber will now be put back into service as the backup filter in that train. The water level in 1T-101 must be checked before the carbon exchange operation will be started and the level maneuvered as necessary to handle the carbon transfer manipulations.

3.1.5 Treated Water

The water in 1T-102 will be treated and most of it is reinjected in the plume area from which it came. Pumps 1P-102A/B pump into the reinjection header. The flow will be controlled by the level in the tank (1T-102).

A part of the treated water will be used for the backwashing of the Greensand filter and the carbon exchange operation of the carbon adsorption system. There will also be in-plant flushing and washing operations.

The treated water going to the reinjection wells receives a controlled amount of H_2O_2 to replace the dissolved oxygen removed in processing. There will also be provisions for the shock, or continuous feed of NaOCl as a Biocide to control biological action and prevent biological plugging of the reinjection wells.



The treated water to the 14 reinjection wells will be regulated at each well head with an electric, remote-operated in-line motorized control valve in the well vault.

3.2 COMPLIANCE WITH THE REGULATORY REQUIREMENTS

The following sections discuss how the SD-5 plume response project meets the regulatory requirements described in Section 2.6.

3.2.1 Compliance with the Requirements of the Federal ARARs

Clean Air Act

Air emissions from the SD-5 plume response project will be minimal. There will be no emissions of carbon monoxide, nitrogen dioxides and sulfur dioxide. Emissions of particulates, VOCs, and hazardous air pollutants will be de minimus. The SD-5 plume response project does not include the installation of any boilers and fired heaters, and thus will not generate carbon monoxide, nitrogen dioxide, or sulfur dioxide.

Potassium permanganate will be handled in bags of crystals. The bags will be opened inside the treatment buildings where the permanganate will be dissolved in water. Because the permanganate is handled in crystal form, there will be minimal dusting and de minimus particulate air emissions.

No compounds have been detected in the groundwater plume, which have specific air emission control requirements under the NESHAP regulations. The groundwater will be exposed to the air in the influent treatment tanks, which will have fixed roofs, but the concentration in the water is so low that air emissions will be de minimus. There are no air strippers or other treatment operations that will strip organics into the air. To confirm that the air emissions are negligible, the emissions were modeled using the EPA "Water 8" program. Using this program, the calculated emissions are:

<u>Compound</u>	<u>Air Emissions Mg/Year</u>
Ethylbenzene	0.5437 E-04
Tetrachloroethene	0.7137 E-04
Toluene	0.206 E-04
Xylenes	0.90259 E-04
TOTAL ALL COMPOUNDS	2.3659 E-04

A number of the compounds on the list of hazardous air pollutants (HAPs) are present in the groundwater in μ /liter concentrations. However, because of the low concentrations in the water any air emissions will be de minimus.

Clean Water Act

Spill control has been designed into the SD-5 treatment system. In addition, the following treatment operations will be provided to remove contaminants from the groundwater before reinjection:

- pH control, to improve operation of the Greensand filters.
- Greensand filters for total suspended solids (TSS), iron, and manganese removal, as a pre-treatment for the downstream treatment systems.
- Carbon treatment, either activated carbon or synthetic carbon, for the removal of organic compounds.

40CFR125 specifies that best management practices (BMPs) be used to prevent spills and leaks from discharging from the facility. The SD-5 treatment system will be installed on curbed concrete pads that will contain the contents of the largest tank (23,000 gallons). All truck loading and unloading operations will be conducted inside the pad area for containment. The concrete pads slope toward collection trenches which discharge into a containment sump. The containment volume is:

• Sump	942 gallons
• Trenches	11,512
• Sloped portion of concrete pad	<u>11,313</u>
TOTAL	23,767

In addition, a separate concrete dike is installed around the caustic tank. The dimensions of the concrete dike are 25 feet long x 11 feet wide x 3 feet high for a containment volume of 825 cubic feet.

40CFR403 sets maximum discharge concentrations for contaminants in the water. These concentration standards will be met because the design basis is to design to remove the toxic organic compounds to below the detection limit.

Safe Drinking Water Act

40CFR141 sets maximum contaminant levels (MCLs). The use of Greensand filters will reduce the concentration of iron and manganese to below the secondary MCLs. The specified iron and manganese discharge concentrations are:

• Iron	Effluent = 0.024 mg/l	MCL = 0.3 mg/l
• Manganese	Effluent = 0.0044 mg/l	MCL = 0.05 mg/l

The activated carbon filters will remove the higher molecular weight organic contaminants to below the detection levels. The specified effluent concentrations are:

• Benzene	Effluent = non detect	(<0.1 µg/l)	MCL = 5 µg/l
• EDB	Effluent = non detect	(<0.02 µg/l)	MCL = 0.02 µg/l
• 1,2 - DCE	Effluent = non detect	(<0.07 µg/l)	MCL = 5 µg/l
• 1,1,1 - TCE	Effluent = non detect	(<0.03 µg/l)	MCL = 5 µg/l
• 1,1,2 - TCE	Effluent = non detect	(<1.0 µg/l)	MCL = 5 µg/l
• PCE	Effluent = non detect	(<0.3 µg/l)	MCL = 5 µg/l
• 1,1,1,2-TCA	Effluent = non detect	(<0.5 µg/l)	MCL = Listed ¹



- 1,1,2,2-TCA Effluent = non detect (<0.4 µg/l) MCL = Listed¹

¹ Listed for promulgation

Resource Conservation and Recovery Act (RCRA)

40CFR261 provides the definition of solid and hazardous waste. The following are the solid waste residuals that may be generated during the SD-5 plume response project, along with a discussion of what provisions will be made to handle the residuals if the residuals fail the TCLP test:

- Drill cuttings: The concentration of contaminants in the groundwater is in the microgram/liter range so it is unlikely that the cuttings will be a characteristic waste. However, the cuttings will be tested and handled as required by the regulations. (Installation activities only).
- The sludge removed from the Greensand filters will contain the suspended solids, iron, and manganese that is present in the influent. The sludge will also contain organic compounds in essentially the same concentration range as in the groundwater plumes. This sludge is not likely to fail the TCLP test, but the sludge loadout facilities have been designed to fully contain the volume of both the settling tank and the sludge hauling truck to meet the RCRA requirements for storage and truck loadout facilities. The sludge will be disposed of at a facility permitted to receive the waste. Since the sludge is not expected to exhibit the characteristics of a hazardous waste and will contain iron coagulants which will be beneficial to wastewater-treatment systems, it may be desirable to send the sludge to a wastewater treatment system, possibly the existing wastewater treatment system at the base.
- Spent activated carbon may be sent offsite for regeneration. The organic compounds in the influent water will be concentrated in the carbon, so it is possible that the carbon will be an EP toxic waste. The carbon loadout facilities have been designed to meet the RCRA requirements for a truck loading facility. Containment has been provided to handle the full volume of

the carbon trucks. The spent carbon will be hauled to a carbon regeneration facility that is permitted to regenerate carbon that is a hazardous waste.

The extracted groundwater will not be a hazardous waste because the concentration of organics in the groundwater is in the $\mu\text{g/l}$ range. Nevertheless, the underground piping and the treatment system has been designed with leak and spill protection that meets RCRA requirements. The following safety factors have been built into the design:

- Double walled piping is used for all untreated groundwater. The double walled piping will be equipped with leak detection tape that will detect any failure of the main piping that releases water, plus will detect any water that infiltrates because of failure of the outer containment piping.
- All the tanks and vessels in the treatment area will either be elevated or will be mounted on concrete foundations that will allow visual observation of any leaks.
- All the treatment equipment and the truck unloading/loadout facilities will be located inside treatment buildings on a concrete pad designed to hold the entire contents of the largest tank. Since the treatment facilities are located inside buildings, the pads will not be required to contain rainfall.

3.2.2 Compliance with the Commonwealth of Massachusetts ARARs

302 CMR 6: Adopting Inland Wetland Orders

None of the activities associated with the SD-5 plume response project will impact wetlands.

310 CMR 6: Ambient Air Quality Standards for the Commonwealth of Massachusetts

This chapter lists the ambient air standards for sulfur dioxides, particulates, carbon monoxide, ozone, nitrogen oxides, and lead.

The project will not be installing any boilers or fired heaters so there will be no emissions of sulfur dioxide, carbon monoxide, or nitrogen oxides.

Potassium permanganate will be handled in bags of crystals, and will be emptied from the bags and dissolved in water. Because the materials are received in crystalline form, instead of powder or granules, there will be no particulate air emissions caused by dusting.

Organic compounds are only present in the plume in μ /liter concentrations and there are no treatment processes that strip organics into the air, so VOC emissions will be de minimus. Since the VOC emissions are de minimus, there will be no impact on ambient air ozone concentrations.

310 CMR 7: Air Pollution Control

The SD-5 plume response project is exempt from the air permitting requirements for the following reasons:

- The air emissions are less than one ton/year, and thus are exempted per 310 CMR 7.02 subsection (4)(a). The total calculated air emissions are 0.0002366 Mg/yr.
- 310 CMR 7.03 subsection (14) provides an exemption for groundwater remediation systems as long as control systems are used to achieve a 95% reduction in air emissions. As listed above, air emissions are de minimus, <0.0002366 Mg/yr. so the exemption is not applicable.

An additional exemption provided by 314 CMR 0049, an exemption from the 95% control requirement if the air emission can be demonstrated as protective of the public health, will not be used by the project.

310 CMR 15: The State Environmental Code. Title 5: Standard Requirements for the Siting, Construction, Inspection, Upgrade and Expansion of On-site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage

Section 15.003 specifies that septage systems operated by an agency of the Federal Government is exempt from the requirement to obtain a construction permit. The SD-5 plume response project is being constructed and will be operated by the U. S. Department of Defense (DOD) and thus are exempt from permit requirements. However, this document contains all the information required to be included in a permit application and thus meets the requirements of this section.

Section 15.260 provides design information for tight tanks. This regulation restricts the use of tight tanks to special situations such as boat waste pumpouts and public water supply systems. The SD-5 treatment system location is remote from the base sewage treatment system, so it is not practical to tie into the existing system.

A "tight tank" will be used to collect sewage from the treatment system. A tight tank is considered to be a preferred alternate to a septic tank system.

310 CMR 22: Drinking Water Regulations

Chapters 22.05 through 22.11 list the maximum allowable concentrations of contaminants in drinking water and requires that certified labs be used to conduct the sample analysis. Bottled water that meets these standards will be supplied as drinking water at the SD-5 treatment system.

Part of the treated water from the effluent tank will be chlorinated for miscellaneous uses, other than injection, that require water that meets potable water standards. These miscellaneous uses include: toilets, safety showers, and eyewash stations. The chlorinated water system is shown on the P&IDs, included

in Volume II. This chlorinated water system meets the requirements of potable water systems for the following reasons:

- The effluent water will be routinely sampled and analyzed using EPA method 504, to confirm that the treated water meets the drinking water standards. A Massachusetts certified lab will be used for all the analyses.
- The treatment system has been designed to remove iron and manganese to below the Massachusetts MCLs of 300 ppb iron and 50 ppb manganese.
- The treatment system has been designed to remove toxic organic contaminants to below the detection limit.
- The water will be chlorinated.
- The water will not be used for human consumption. (Bottled water will be provided for consumption).

310 CMR 27: Underground Water Source Protection

Section 27.03 lists the Classes of injection wells. The reinjection wells are Class V wells. They are not Class I through IV.

- Class I wells inject hazardous waste fluids below the lowermost drinking water aquifer.
- Class II wells inject fluid brought to the surface during oil or natural gas production.
- Class III wells inject fluids for the extraction of minerals.
- Class IV wells inject hazardous or radioactive wastes into or above an aquifer.

Class I through IV wells are prohibited.

Class V wells are only allowed as long as they do not cause or allow movement of contaminants into underground sources of drinking water.

The reinjection wells for the SD-5 plume remediation project are allowed by this project because:

- The design basis for the treatment system is to remove toxic organic contaminants to below the detection limit.
- Extraction wells and reinjection wells are located close together to prevent disturbing the natural groundwater flows in the area and thus not affect the flow of contamination toward any drinking water sources.

310 CMR 30: Hazardous Waste

Section 30.102 lists the methods for the identification of hazardous waste. Wastes which will be generated by construction or operation of the SD-5 plume containment system include:

- Drill cuttings and water generated during the installation and development of the wells.
- Solids collected during backwash of the filters
- Spent activated carbon

Of the three residues listed above, the first two are very unlikely to fail the TCLP test and thus are unlikely to be hazardous wastes. Nevertheless, all residues will be tested and will be handled and disposed of per the regulations. The organic compounds will concentrate in the activated carbon, so the spent carbon may fail the TCLP test. To be certain, the carbon loadout facilities are designed with full secondary containment per the hazardous waste regulations, and the carbon will be shipped for regeneration to facilities permitted to handle the waste.

Section 30.354 lists the general requirements for hazardous waste treatment, storage, and disposal facilities (TSD). The groundwater in the SD-5 plume is very dilute, so the extracted groundwater will not be a hazardous waste. Even though it is not required by the regulations, both the piping from the extraction wells and

the treatment system is designed to meet the following secondary containment requirements.

- Double walled piping, with continuous leak detection cable, will be provided for the buried pipe from the extraction wells.
- All the tanks will be elevated or installed on foundations that will allow the visible detection of leaks.
- The treatment system will be installed over a concrete pad that will hold the contents of the largest tank, 23,000 gallons. The volumes of each section of the containment system are:

Volume of the sump	942 gallons
Volume of the trenches	11,512
Volume of the pad	11,313
Total	23,767

- Water stops will be used to seal the joints in the concrete
- Any spills or leaks will flow through trenches to a sump where an alarm will sound if the water level monitor detects any leaks or spills.

Section 30.402 lists the requirements for the transport of hazardous waste. Spent carbon from the treatment system may exhibit the characteristics of a hazardous waste. If the carbon is a hazardous waste it will be manifested, shipped to permitted regeneration facilities, and shipped using permitted haulers.

Section 30.693 lists design and installation requirements for hazardous waste tank systems. The SD-5 treatment system will not be a hazardous waste system, however, all the tanks will be designed with full secondary containment to meet the intention of this section.

Section 30.694 lists requirements for the containment and leaks from hazardous waste facilities. As mentioned above, even though the SD-5 plume containment



system is not a hazardous waste facility it will still be designed with full secondary containment and leak detection to meet the requirements of this section.

Sections 30.695, 696, and 697 list operating, inspection, and response requirements to prevent or control leaks and spills from hazardous waste facilities. To meet the requirements of these sections, the following items have been included in the design of the SD-5 plume containment facility:

- The underground piping from the wells will be constructed of double-walled HDPE pipe which is resistant to corrosion from both the extracted water and the environment.
- The tanks and treatment vessels are all either lined, or constructed of stainless steel, for corrosion resistance.
- High level alarms are provided on all tanks to prevent overfilling.
- The tanks all have covers and they are installed in a building, so freeboard for rainfall is not required.
- A high level alarm in the area sump will warn the operator of a spill or leak.

310 CMR 40: Massachusetts Contingency Plan

Section 40.0041 states that any water discharged within 200 feet of "Outstanding Resource Water" must meet groundwater quality standards and a permit is required for discharge to the groundwater. The contents of this document provide the information required in a permit application. Also, the quality of water discharged from the SD-5 plume containment facility will meet all the required groundwater quality standards. The contaminants in the discharge from the treatment system will all be below the MCLs and secondary MCLs. The system is further designed to remove toxic organic contaminants to below their respective detection limits.

Section 40.0045 lists specific requirements for the discharge of remediation effluent to the groundwater. The following describes how the effluent from the FS-12 plume containment project meets the requirements of this section.

The discharge must meet the requirements of 314 CMR 6.0:

- The iron concentration will be less than 0.3 mg/l. Iron will be removed in the Greensand filters as a pre-treatment to prevent fouling the carbon beds.
- The manganese concentration will be less than 0.05 mg/l. Manganese will be removed in the Greensand filters.
- The total dissolved solids must be less than 1000 mg/l to meet the requirements.. The expected concentration is essentially the same as the existing groundwater concentration (approximately 34 mg/l), thus meeting this requirement.
- The influent water will be neutralized if required to remove the iron and manganese. The re-injected water will either be at the pH of the natural groundwater, or will be neutralized to a pH between 6.5 and 8.5.
- The nitrate concentration must be less than 10 mg/l. The treatment system will not add nitrate-nitrogen and thus will not affect the concentration of this compound in the plume. Nitrate is less than 10 mg/l based on past plume sampling.
- The concentration of all other contaminants in the plume will be less than the MCLs and secondary MCLs.
- Facilities have been provided to allow the injection of sodium hypochlorite into the reinjection water, if needed, to control biological fouling around the reinjection wells. Since chlorine is not stable, the hypochlorite will be reduced to sodium chloride in the groundwater.
- Facilities are also provided for the injection of hydrogen peroxide to raise the dissolved oxygen concentration of the groundwater.

The discharge will not cause groundwater mounding within two feet of the surface for the following reasons:

- The treated water is being reinjected in close proximity to the point where the water is being extracted.
- The depth to groundwater is between 38 and 53 feet in the area of the reinjection wells.
- The groundwater modeling shows a mounding of only 0.25 feet in the area of the reinjection wells, see Figures 3-1 and 3-2. Thus, the water level in Ashumet and Johns Pond will not be affected.
- The system will be started up slowly.

The discharge will not result in flooding or breakout to the ground surface for the reasons listed above.

The discharge will not exacerbate existing conditions or impair the remediation of existing conditions because the treated water is being reinjected in the vicinity of where the water is extracted.

Section 40.0049 allows an exemption for groundwater remediation projects from the 95% control requirements for air emissions, if it can be demonstrated that the emissions present no risk to public health. The concentration of VOCs in the plume are so low and there are no treatment activities that strip VOCs to the air, so air emissions are de minimis and use of this exemption is not required.

Section 40.0874 lists the contents of a Remedial Implementation Plan (RIP). The requirements of this section are satisfied by submission of this report as demonstrated by the following cross reference between the requirements in this section (section 3.2) and the contents of this report:

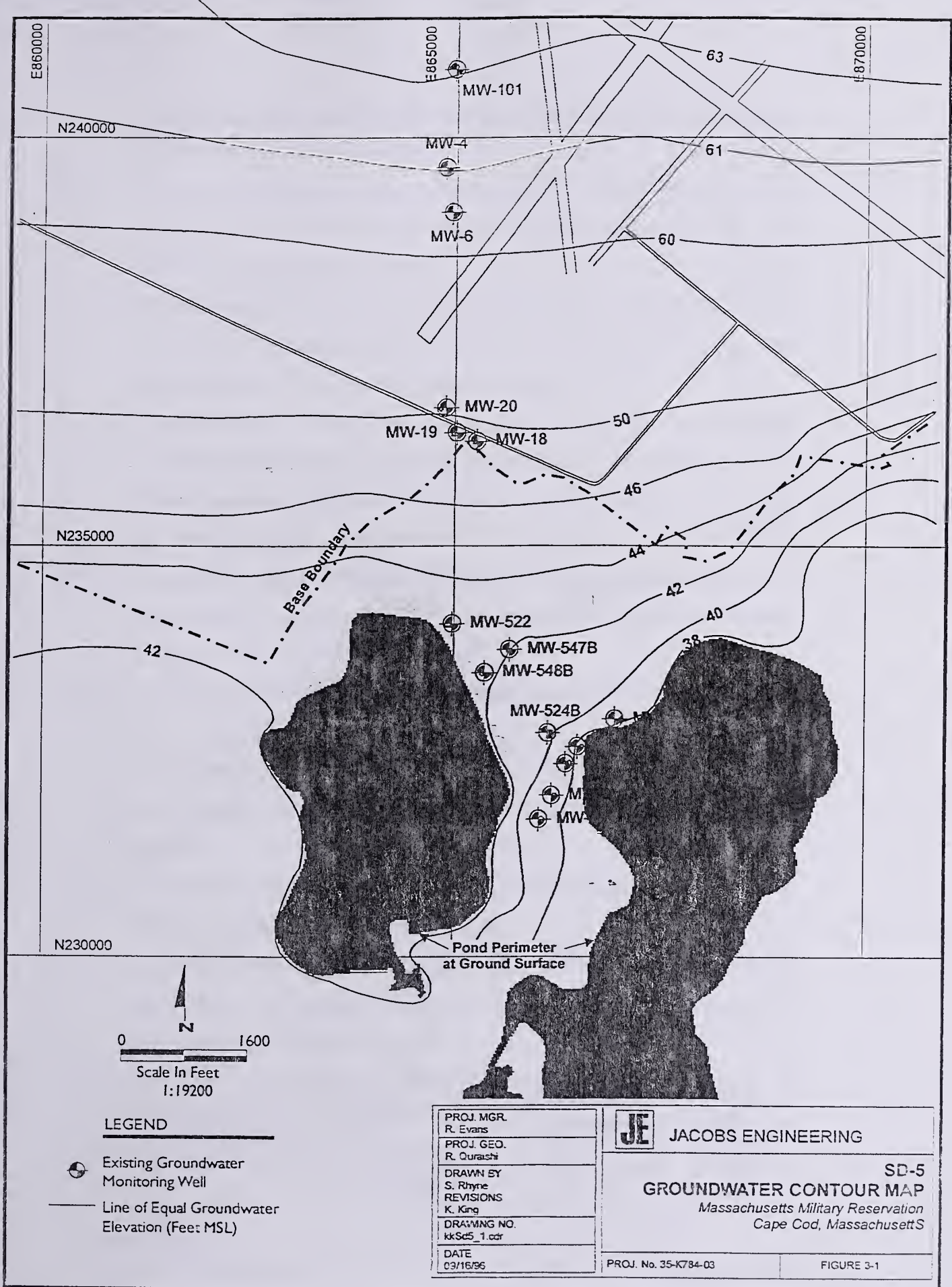
- The goals of the project are listed in section 2.0, Basis of Design



- All new information about the site is included in section 2.0
- Disposal site maps are included in section 1.0, Introduction, and in Volume II.



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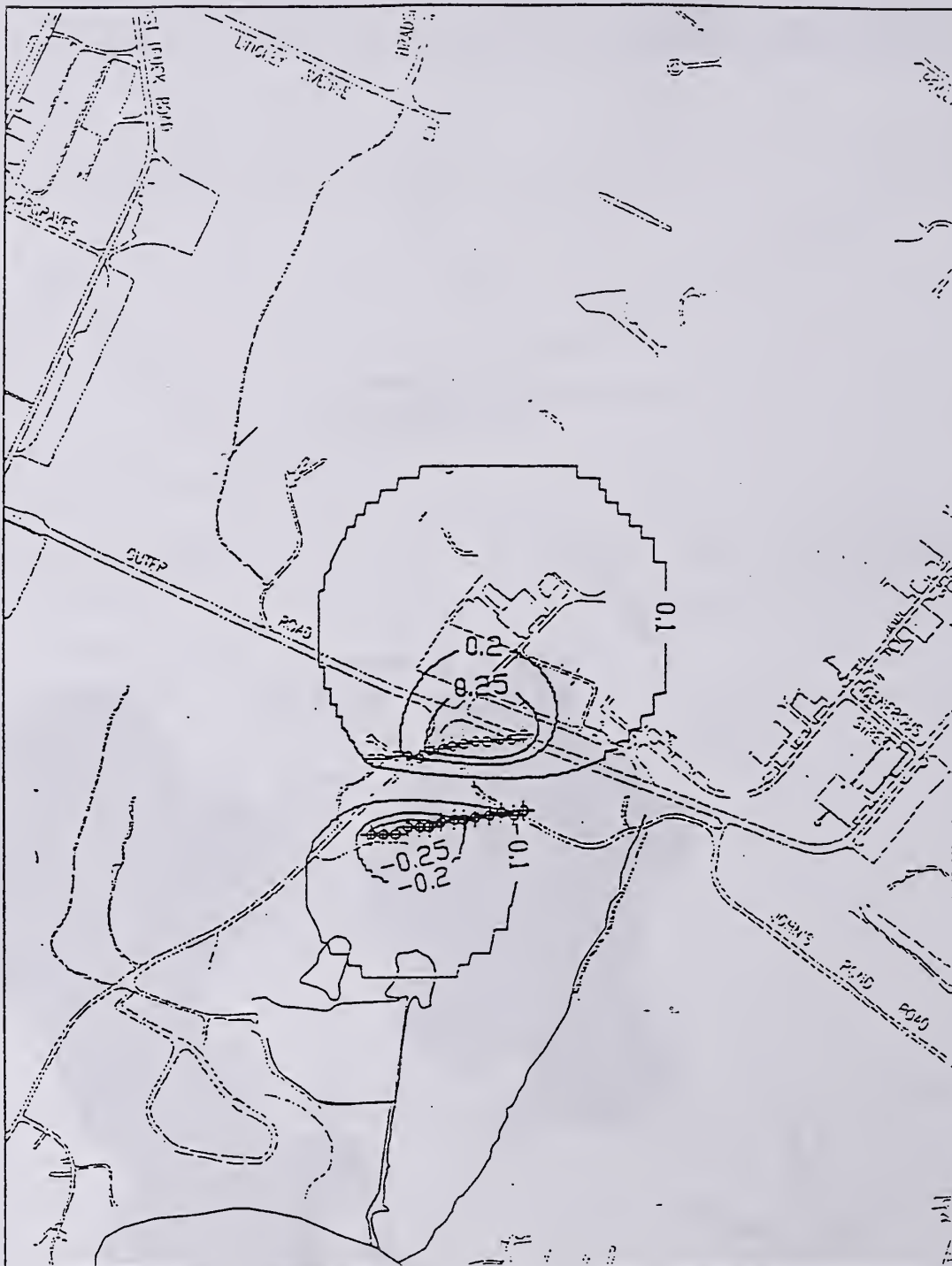


LEGEND

- Existing Groundwater Monitoring Well
- Line of Equal Groundwater Elevation (Feet: MSL)

PROJ. MGR. R. Evans
PROJ. GEO. R. Ourashi
DRAWN BY S. Rhyne
REVISIONS K. King
DRAWING NO. kkScd5_1.cdr
DATE 09/16/96

JE JACOBS ENGINEERING	SD-5
	GROUNDWATER CONTOUR MAP
	Massachusetts Military Reservation Cape Cod, Massachusetts
PROJ. No. 35-K784-03	FIGURE 3-1



Environmental Consulting Engineers



P.O. Box 22568
Knoxville, TN 37933
Phone: (423) 891-3668
Fax: (423) 891-0611

SD-3 Scenario B Run 9 (365 gpm) Drawdown

Massachusetts Military Reservation

Drawing Version No.: Page 2
Drawn by: BTM
Checked by: MLC
Drawing Name: SD39WT.DWG
Project No: 01 VMP 01

Drawing No.

56.09.CD

- A description of the characteristics and quantity of the contaminated groundwater is included in section 2.0.
- A detailed description of the treatment units is included in section 4.0, Description and Layout for Key System Components, and in section 5.0, Extraction and Reinjection Systems.
- Relevant design and operation parameters are listed in section 3.0, Description of Treatment Processes, which also includes information on pilot tests that demonstrate the efficiency of the treatment systems.
- Design features for control of hazardous material spills and accidental discharges are discussed in section 4.3, Treatment System Containment.
- The management of residuals is discussed in section 4.0 and in section 6.0, Operational Philosophy and Safeguards.
- The identification of site-specific characteristics is included in section 2.0.
- A discussion of the measures taken to protect the environment is included in sections 2.0 and 3.0.
- A description of the inspection and monitoring is included in section 6.0

Section 40.0890 lists the requirements for operation and maintenance of the remedial action. The following describes how the requirements of this section will be met:

- The effluent from the treatment system will be sampled and analyzed to insure that the treatment requirements are being met.
- Monitoring wells are being installed. These wells will be sampled and analyzed, plus groundwater levels will be determined, to insure that the SD-5 plume is being contained as required.
- Operating and maintenance records will be maintained at the site.
- The equipment will be inspected and monitored as required to maintain the performance efficiency of the equipment.

314 CMR 2: Permit Procedures

This section states that the discharge to groundwater be permitted. The contents of this report provides the information required for permitting.

314 CMR 5: Groundwater Discharge Permit Program

Section 5.03 states that a permit application must be filed before treated water can be discharged below the land surface. This report provides the information required for the permit application.

Section 5.04 requires that a discharge permit be obtained for any stormwater that has come in contact with process wastes. As shown on the treatment system layout drawings in Volume II, secondary containment is provided for the extracted water and treatment system plus the treatment system will be located in a building to insure that stormwater will not contact the process wastes.

Section 5.10 lists effluent concentration limits. The SD-5 plume containment system will meet the primary effluent limits for Class I and Class II groundwaters as follows:

- Toxic pollutants will be removed by the treatment system to well below the MCLs. In fact, the treatment system has been designed to remove toxic organic contaminants to below the detection limit.
- The concentrations, in the SD-5 plume, of all other primary contaminants are below the listed treatment levels listed in this section.

The treatment system will also meet the following secondary effluent limitations:

- Iron will be removed to below 0.3 mg/l.
- Manganese will be removed to below 0.05 mg/l.
- The pH will either be the same as the pH of the natural groundwater, or will be adjusted to between 6.5 and 8.5.

- Nitrate nitrogen will be below 10 mg/l. The treatment system will not change the nitrate nitrogen concentration, which is below 10 mg/l in the plume.
- The total nitrogen concentration will be below 10 mg/l. The treatment system will not add nitrogen. If high molecular weight nitrogen compounds are present they will be removed by the treatment system so the reinjected water will be at or below the natural concentration in the SD-5 plume.
- The chloride concentration will be below 250 mg/l. The natural chloride concentration in the plume is approximately 10 mg/l this will not be changed by the treatment system.
- The total dissolved solid concentration will be less than 1000 mg/l. The TDS concentration in the SD-5 plume is approximately 34. This will be increased by less than 1% because of the addition of caustic for neutralization of the influent.
- Facilities are provided to add sodium hypochlorite to the water, if required, to control biological fouling around the reinjection wells. This may produce localized concentrations of chlorine in the groundwater, but the chlorine will react with organic compounds and soil and will quickly be reduced to sodium chloride in the groundwater.
- Facilities are provided to add hydrogen peroxide to the reinjected water to raise the dissolved oxygen content.

Section 5.19 lists specific requirements for the discharge to the groundwater that are being met by the SD-5 plume containment system as follows:

- The discharge will not violate the surface water or groundwater quality standards (see the discussions in the previous sections).
- The concentrations in the discharge are well below the requirements of 40CFR307(a).
- All valves that could be accidentally opened to allow bypass of the carbon treatment beds, will be carsealed closed.

314 CMR 6: Groundwater Quality Standards

Section 6.06 lists minimum groundwater quality standards (see the previous discussion on the required groundwater discharge concentrations).

Section 6.07 states that a permit is required to discharge to the groundwater. This report satisfies the requirements for a permit application.

314 CMR 8: Supplemental Requirements for Hazardous Waste Management Facilities

This section requires that any wastewater units that treat, store, or dispose of hazardous waste generated at the site must comply with 310 CMR 30 (see the previous write-up on section 310 CMR 30 for a discussion of compliance with this section).

314 CMR 12: Operation and Maintenance and Pretreatment Standards for Wastewater Treatment

Section 12.03 states that any bypass around a wastewater system must be carsealed closed. There are no bypasses around the SD-5 treatment system.

Section 12.04 states that the system must be maintained to assure that the system meets the effluent requirements. A detailed maintenance plan will be prepared that will spell out the requirements needed to assure maintenance of the facility.

314 CMR 15: The Prevention and Control of Oil Pollution in the Waters of the Commonwealth

The SD-5 treatment system design does not include the storage or use of oils at the site. However, the treatment system design provides for the full containment



of spills and will meet the Best Management Practices (BMPs) for spill containment, if oils are stored at the site in the future.

A concrete pad will be provided at the treatment area. The concrete pad combined with trenches and dikes will hold the volume of the largest tank (23,000 gallons). An additional dike is provided that will hold the contents of the caustic storage tank (4500 gallons).

3.3 PILOT TESTS AND COMMERCIAL EXPERIENCE

Pilot tests were conducted on groundwater collected at MMR to demonstrate that the contaminants in the groundwater could be removed to concentrations below the detection limit. The information from these pilot tests was then supplemented with information from pilot tests conducted on groundwater from other locations, and on the operating experience of commercial carbon treatment systems. The pilot test results combined with other supplemental information demonstrate that:

- Activated carbon will reduce the organic contaminants of concern to below the detection limit. Removal of the contaminants to below the detection limit can be achieved with a residence in the carbon of as little as 4.5 minutes.
- Activated carbon, preceded by a UV/peroxide system, is an economically viable treatment option. The estimated carbon consumption is 20,000 lbs/year, one carbon bed/year. A residence time in the carbon of between 10 and 15 minutes is required to effectively use the capacity of the carbon, and to minimize the carbon replacement frequency.
- Greensand filters will reduce the concentrations of iron and manganese to well below the MCLs of 300 and 50 µg/l respectively.

Specific sources of information used for design of the main treatment facility systems included:

Activated Carbon System

- Laboratory "Isotherms" which define the capacity of carbon to remove various contaminants.
- Granular activated carbon vendor recommendations
- Pilot tests conducted on groundwater obtained from the FS-12 plume and the Eastern Briarwood plumes.
- The performance of systems operating to remove EDB from groundwater in Florida.
- The performance of systems treating groundwater in Massachusetts.

Greensand Filters System

- Vendor recommendations
- Literature on the removal of iron and manganese from drinking water

3.3.1 Granular Activated Carbon

The information used to size the granular activated carbon system was taken from a number of sources:

- Laboratory isotherms
- Granular activated carbon vendor recommendations
- Pilot test data
- The performance of commercial systems in full scale operation

Laboratory Isotherms

Laboratory isotherms are used to conduct the preliminary screening of the economics and effectiveness of removing contaminants from water. The isotherms show the quantity of contaminant that can be adsorbed on a gram of carbon, at various contaminant concentrations. The capacity of the carbon is measured at different concentrations and the results are plotted on log-log paper,

which produces a straight line and allows determination of the slope and intercept of the line (see Appendix C for a more thorough discussion on isotherms).

Isotherms used to screen the effectiveness of carbon in treating the plumes at MMR were obtained from the following sources:

- The EPA RREL database
- Isotherms developed by Calgon Carbon Corporation (CCC)

The isotherms from both the RREL database and from CCC both demonstrate that granular activated carbon is a viable approach to removing the following contaminants from groundwater, the carbon has a strong affinity to adsorb the following compounds:

- Trichloroethene (TCE)
- Perchloroethene (PCE)
- 1,2-Dichloroethene (1,2-DCE)
- 1,2-Dibromoethane (EDB)
- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Tetrachloroethane
- Tetrachloroethene
- Bis (2-Ethylhexyl) phthalate

Isotherms for the above compounds were used to calculate the consumption of carbon. The calculated carbon consumption is 20,000 lbs/year, which is equivalent to replacing one carbon bed/year. These calculations demonstrate that the use of granular activated carbon is a viable treatment option.

Vendors Recommendations

Vendor recommendations on the use of activated carbon in treating the MMR plumes was received on two occasions:

- During procurement of the carbon systems for the Interim Wellhead Treatment System for the Town of Falmouth (Coonamessett Well).
- During development of the original design basis for treatment of the MMR plumes.

Requests for proposals were issued to carbon vendors, for a carbon treatment system to treat the discharge from the Coonamessett Well. To be conservative, the requests for proposal listed the following highest concentrations of contaminants detected in the CS-4 plume:

EDB	0.14 µg/l
TCE	13 µg/l
Toluene	24 µg/l
PCE	24 µg/l
1,1-DCE	17 µg/l
1,1,2,2-PCA	56 µg/l

Three vendors quoted activated carbon treatment systems. All three vendors, including the selected vendor (Calgon Carbon Corporation) recommended the use of two 20,000 pound carbon beds. The vendors stated that the residence time in each bed would be 7.5 minutes, which based on their experience, was a long enough contact time to reduce the above concentrations to below the detection limit. These recommendations are consistent with pilot plant data which demonstrated that non-detect concentrations can be achieved with a 4.5 minute residence time.

In February, 1995 Calgon Carbon Corporation was asked to provide recommendations for carbon system contact times for each of the MMR plumes under consideration at the time. The following was Calgon's recommendations:

<u>Plume</u>	<u>Contact Time, min.</u>	<u>Breakthrough Contaminant</u>
FS-12	7.0	EDB
SD-5	7.5	TCE, 1,2-DCE, PCE
LF-1	10.0	Vinyl Chloride
CS-10	7.5	TCE, 1,2-DCE, PCE
Ashumet	8.7	TCE, 1,2-DCE, PCE

Based on the above recommendations, a design basis contact time, for the carbon systems at every plume, was set at 10 minutes. The 10 minutes was selected, to be conservative, to match the highest recommendation for any of the plumes.

In summary, based on vendor recommendations the design residence time for the SD-5 carbon system should be between 7.0 minutes and 10 minutes. This is a longer residence time than the 4.5 minutes demonstrated, in pilot tests, to remove the organic compounds of concern to below the detection limit.

Pilot Test Data

During 1995, samples were collected from the FS-12 and Eastern Briarwood plumes, and pilot tests were conducted to demonstrate that granular activated carbon could be used to reduce the concentrations of EDB, benzene and lead to below the detection limits.

EDB and Benzene Removal Pilot Tests

During the evaluation of treatment options for contaminant plumes at MMR, pilot tests were conducted to determine the removal efficiency of EDB and benzene



using activated carbon. The tests were conducted by HPW Systems of Humble, Texas in November 1995.

The pilot system consisted of a 55 gallon drum of Calgon Carbon Corporation activated carbon. The drum contained approximately six cubic feet of carbon. The water tested was collected from monitoring well GMW-20, located in the "hot spot" of the FS-12 plume. This well was tested because of its high known concentrations of both benzene and EDB. The measured benzene concentration was 1800 $\mu\text{g/l}$, and the EDB concentration was 300 $\mu\text{g/l}$. These concentrations are more than 100 times as high as the concentrations expected in the feed to the SD-5 treatment system.

The flow rate through the treatment system was 10 gpm for a contact time of 4.5 minutes. During these tests both the benzene and the EDB were removed to below the detection limit as indicated by the following data:

	<u>Influent, ppb</u>	<u>Effluent, ppb</u>
Benzene	1800	ND(<5.0)
EDB	300	ND(<0.015)

This pilot test demonstrates that with a residence time of 4.5 minutes in the carbon bed, the EDB and benzene concentrations can be reduced to below the detection limits, from considerably higher concentrations than are expected in the treatment system influent.

Lead Removal Pilot Tests

From September 26 through September 28, 1995, onsite tests were conducted to demonstrate that granular activated carbon could be used to reduce lead concentrations in the groundwater to below the detection limit.

The water for the test was collected from monitoring well FTA-3/MW-3 in the Eastern Briarwood plume. The water from this well contained 3.6 ppb lead, which is in excess of the concentration expected in the SD-5 plume. The test was conducted using a 55 gallon drum that contained approximately 6 cubic feet of carbon. The flow rate to the carbon was 5 gpm, which is equivalent to a contact time of 9 minutes. The following were the results of the pilot tests:

Influent Sample	3.6 ppb
Effluent after 200 gallons	ND (<1.0 ppb)
Effluent after 1000 gallons	ND (<1.0 ppb)

The results show that activated carbon can remove lead from the MMR groundwater. The lead can be removed to below the detection limit using a residence time in the carbon bed of 9 minutes.

Note: Additional information on the pilot plant test work is contained in the "Draft Final, Installation Restoration Program, Plume Containment Design Analysis Plan, Volume IV, Appendices A - C", dated January 1996.

Performance of Commercial Systems in Full Scale Operation

Granular activated carbon is being successfully used in commercial operations, a number of which are in Massachusetts, to remove contaminants from groundwater and drinking water to below the detection limits. Information on the following systems are included in Appendix C:

- Removing EDB from drinking water (Florida)



- Potable Groundwater Treatment system (Groveland, Massachusetts)
- Potable Groundwater Treatment system (Town of Marshfield, Massachusetts)
- Activated Carbon Treatment Restores Acton Water Supply (Acton, Massachusetts)

The first article is the result of work conducted in Florida on the treatment of potable water contaminated with EDB. Activated carbon has been used extensively to reduce the EDB concentrations in the groundwater to below the detection limit of 0.02 µg/l. Treatment systems described in the article include:

- Initial tests on two private wells that reduced the EDB concentrations from 10 and 700 µg/l respectively, to below 0.02 µg/l. These designs have since been expanded to treat the water from 500 private wells.
- Carbon systems have been installed to treat 9 public water systems, with capacities up to 4.3 MM gallons/day. The design residence time of the systems ranges from 5 to 12 minutes.
- Extensive data collected on two systems demonstrated that the carbon consumption closely matched the consumption predicted from laboratory tests.

Carbon beds installed to treat potable water being discharged from Groveland Well No. 1 in Groveland, Massachusetts have been reducing TCE concentrations from 400 ppb to less than 2.5 ppb. The system operates with two carbon beds in series with a residence time of 13 minutes/bed or 26 minutes total.

Carbon beds installed to treat the water from Furnace Brook No. 1 well, in the Town of Marshfield, Massachusetts, reduce the PCE concentration in the potable water from 30 ppb to below the detection limit (<1 ppb). Two carbon beds operate in parallel, each with a residence time of 15 minutes.

Two carbon beds were installed in series to treat the potable water from Assabet No. 1 well in Acton, Massachusetts. The system has successfully treated groundwater containing over 150 ppb of TCE and 1,1-DCE to meet the standard of less than 5 ppb total VOCs. The residence time in the carbon system is 15 minutes/bed.

3.3.2 Greensand Filter Design

Based on recommendations from the Greensand filter vendors, pilot tests were not conducted to verify the performance of the filters. The vendors indicated that the use of Greensand filters to remove iron and manganese from drinking water supplies is a standard technology, with hundreds of systems in operation in the United States. A number of vendors were presented with the required iron and manganese treatment levels:

Iron	Influent = 243 µg/l	Effluent = <24µg/l
Manganese	Influent = 44 µg/l	Effluent = <4.4 µg/l

Each vendor indicated that the above proposed treatment concentrations can be easily achieved using Greensand filter technology.

Appendix E contains the standard Greensand literature of the following companies:

- Kisko Water Treatment Company
- Roberts Filter Manufacturing Company

The literature from these companies contains the following design information that was used as a basis for sizing the SD-5 treatment system:

Potassium permanganate addition = (1 X ppm iron) plus (2 X ppm manganese)

Flow rate through the filter = 2 to 5 gpm/ft²

Allowable solids loading = 7000 grains/ft² (one lb/ft²)

Required backwash rate = 12 gpm/ft²

3.4 Alternate Technologies Considered

A review of the potentially applicable process technology types and process options were evaluated with respect to technical implementability. Chemical treatment technology has been identified as the response action for the MMR's plumes. A technical analysis of the prime options was examined for reliability, implementability, safety, and likelihood of meeting the treatment goals. A cost analysis, including capital and construction estimates was considered. Finally, a number of institutional concerns were addressed, including regulatory considerations, on-site and off-site requirements, worker health and safety issues, worker and community relations benefits, and the ability to maintain all environmental and ecological protection considerations.

Description of Process Technologies Considered

Chemical treatment of groundwater is the process by which hazardous wastes are chemically changed to remove toxic contaminants. The types of treatment included in this review are oxidation/reduction, ozonation, ion exchange, air stripping, membrane and ion exchange for the treatment of organic contamination. To prepare the water for organic treatment the suspended solids, iron, and manganese need to be removed.

Sand filters are frequently used to remove fine sediment or silts from water. This is straight forward technology that has been used for centuries. Sediment is normally removed as a first step in water treatment. This allows the water to flow through other process equipment with minimum plugging and less treatment interference.



Treatment is also required to remove the metals (iron and manganese). Four technologies were reviewed. They included a Greensand filter, resins, chelation, and chemical precipitation. The Greensand filter was selected based on operational, maintenance and reliability requirements, and because it can also serve as a sand filter to remove suspended solids.

The next step is to remove the organic chemicals of concern. Seven technologies were evaluated. They are UV/oxidation, ozonation, clays, air stripping, ion exchange, membrane, and synthetic carbon (see Figure 3-3). A brief description of the technologies follows:

- UV/oxidation is a technology in which chemical reactions cause atoms or groups of atoms to lose electrons, hence oxidation/reduction is the transfer of electrons. In this process the reactions usually cause the contaminants to oxidize. The addition of oxygen breaks down organic waste or chemicals such as benzene, phenols, and organic sulfur compounds. Peroxide is the oxidizing agent normally used in conjunction with UV.
- Ozonation is a technology involving the use of ozone as an oxidizing agent. Ozone is produced with corona discharge technology (water or air is subjected to a high energy electric arc), and must be produced on site due to the hazards of transporting and storing ozone. Ozone oxidation of the contamination is conducted in batch or continuous operations. Note that electrical consumption is high.
- Clays is a technology in which the sorption properties of treated clay are used to capture contaminants from water. The water is passed through clays in a vessel until the clay becomes exhausted. The clay requires disposal.
- Air stripping is the process of bringing about contact between air and water to allow the physical transfer of dissolved molecules from a liquid waste stream to a flowing gas. It is normally carried out as a continuous operation that employs a packed tower. For air stripping, liquid waste is pumped to near the

top of the stripping column and flows downward through the tower, cocurrent to an upward air flow. If required, activated carbon can be used to remove contaminants from the discharged air.

- Ion exchange is a technology by which compounds are removed by the capture of ions on a resinous material known as ion exchange resins. The resin is contained in a column and the wastewater is continuously passed through the column until the resin becomes exhausted, and then is regenerated. Ion exchange is not a destructive technology and the contaminants will require disposal.
- Membrane separation is also called reverse osmosis separation which removes inorganic and organic molecules from wastewater streams. Wastewater is sent through a reverse osmosis system under pressure. The reverse osmosis system filters, then concentrates waste materials while clean water passes through the membrane.
- Synthetic Carbon is a technology by which compounds are removed by the capture of ions on a resinous material known as Ambersorb[®]. The resin is contained in a column and the wastewater is continuously passed through the column until the Ambersorb[®] becomes exhausted, and then is regenerated. This is not a destructive technology and the contaminants will require disposal.

Screening Evaluation

Defined alternatives were evaluated against the short and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation was to reduce the number of alternatives that were to undergo a more thorough and extensive analysis, alternatives were evaluated more generally in this phase than during the detailed analysis. However, evaluations at this time were sufficiently detailed to distinguish among the alternatives. In addition, we ensured that the alternatives were compared on

an equivalent basis (i.e., definitions of treatment alternatives are approximately at the same level of detail to allow preparation of comparable cost estimates).

Initially, specific technologies or process options were evaluated primarily on the basis of whether or not they could meet a particular remedial action objective. During alternative screening, the entire alternative was evaluated as to its effectiveness, implementability, and cost.

During the detailed analysis, the alternatives were evaluated against nine specific criteria and their individual factors rather than the general criteria used in screening. The nine criteria used at the time of screening are shown in Figure 3-3. The relationship between the screening criteria and the nine evaluation criteria is conceptually illustrated in Figure 3-3.

SCREENING CRITERIA

NINE EVALUATION CRITERIA

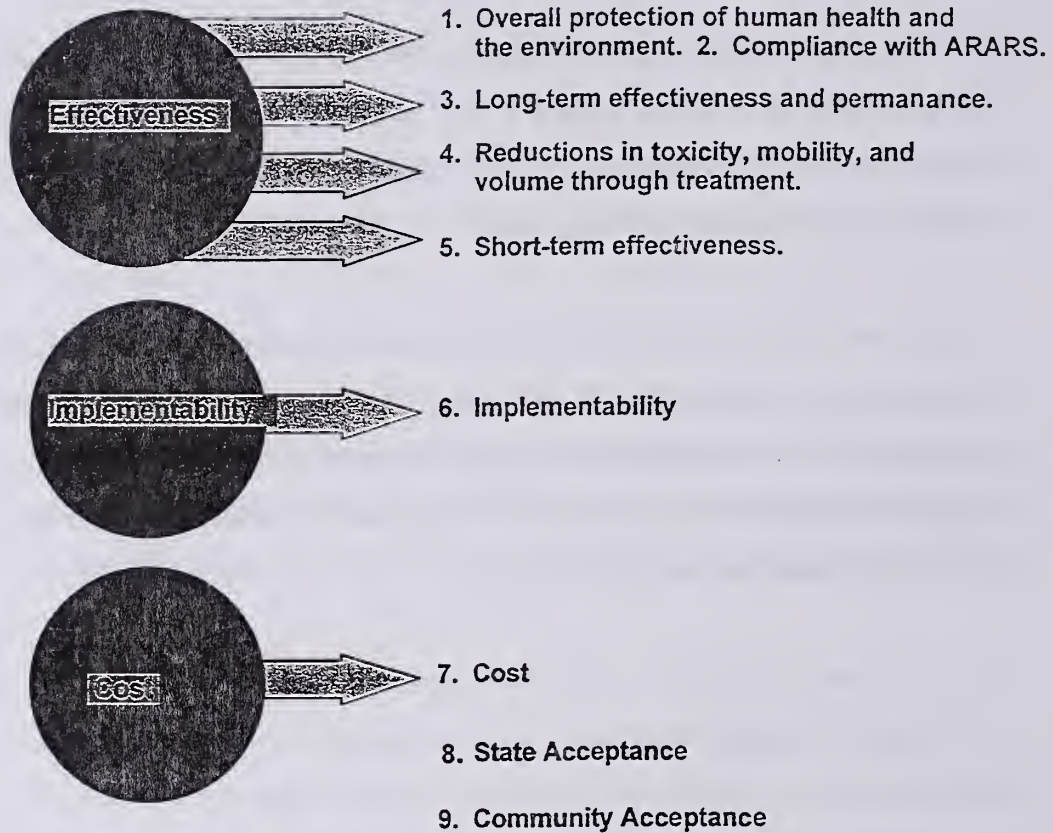


FIGURE 3-3

It is also important to note that comparisons during screening were usually made between similar alternatives (the most promising of which was carried forward for further analysis); whereas, comparisons during the detailed analysis were differentiated across the entire range of alternatives. The criteria used for screening are described in the following sections.

Effectiveness Evaluation

A key aspect of the screening evaluation was the effectiveness of each alternative to protecting human health and the environment. Each alternative was evaluated as to its effectiveness in providing protection and the reductions in toxicity, mobility, or volume that it will achieve. Both short and long-term components of effectiveness were evaluated; short-term referring to the construction and implementation period, and long-term referring to the period after the remedial action will be complete. Reduction to toxicity, mobility, or volume refers to changes in one or more characteristics of the hazardous substances or contaminated groundwater by the use of treatment systems that decrease the inherent threats or risks associated with the hazardous chemicals.

Implementability Evaluation

Implementability, as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial treatment system alternative, was used during screening to evaluate the combinations of process options with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is complete; it also includes operation, maintenance, replacement and monitoring of technical components of an alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from AFCEE and agencies, the availability of treatment, storage, and disposal services and

capacity, and the requirements for, and availability of, specific equipment and technical specialists.

The determination that an alternative was not technically feasible or not available precluded it from further consideration unless steps can be taken to change the conditions responsible for the determination. Negative factors affecting administrative feasibility normally involve coordination steps to lessen the negative aspects of the alternative but would not necessarily eliminate an alternative from consideration.

Cost Evaluation

The focus was to make comparative estimates for treatment alternatives with relative accuracy so that cost decisions among alternatives could be sustained as the accuracy of cost estimates improves beyond the screening process. The procedures used to develop cost estimates for alternative screening were similar to those used for the detailed analysis. The only differences would be in the degree of alternative refinement and in the degree to which cost components were developed.

Cost estimates for screening alternatives typically were based on a variety of cost-estimating data. Basis for screening cost estimates included cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates as modified by site-specific information.

Both capital and O&M costs were considered, where appropriate, during the screening of treatment alternatives. The evaluation included those O&M costs that will be incurred for as long as necessary, even after the initial treatment action is complete. In addition, potential future remedial treatment costs were considered to the extent they can be defined. Present worth analyses were used



during alternative screening to evaluate expenditures that occur over different time periods.

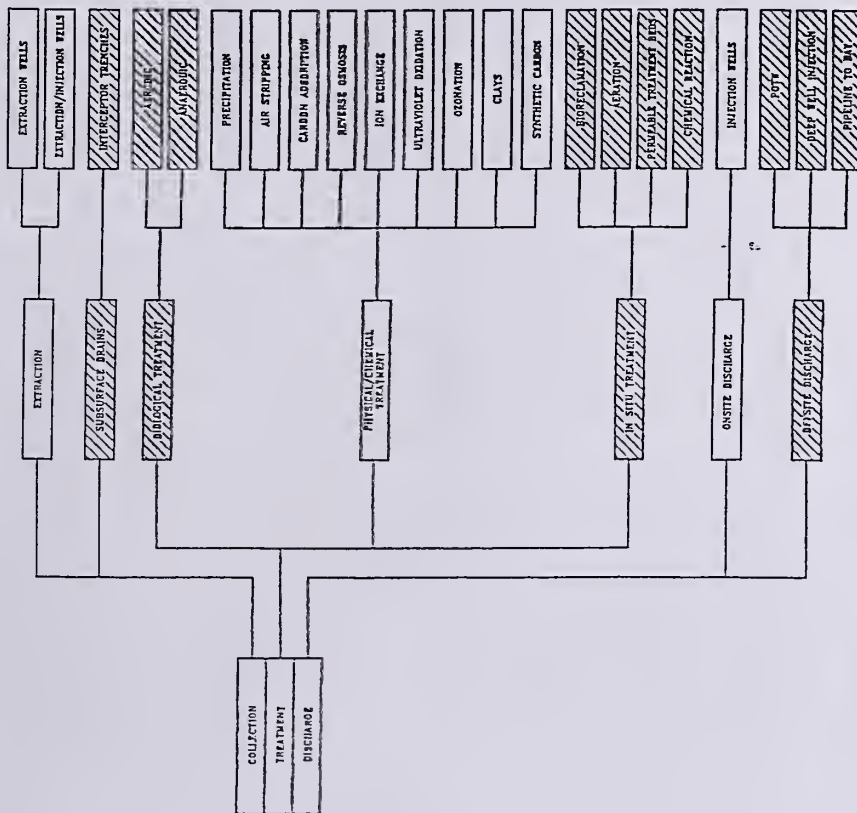
Recommendation

The review has shown that for the task of removing suspended solid and metals, a Greensand filter is recommended based on operational, maintenance and reliability.

The recommended approach for removing toxic organic compounds is to use an activated carbon system to remove the compounds.

A synthetic carbon (Ambersorb) could be used as an alternate to the activated carbon system. This process requires less space, is faster reacting, does not produce fines, is regeneratable on-site and is not biologically fouled.

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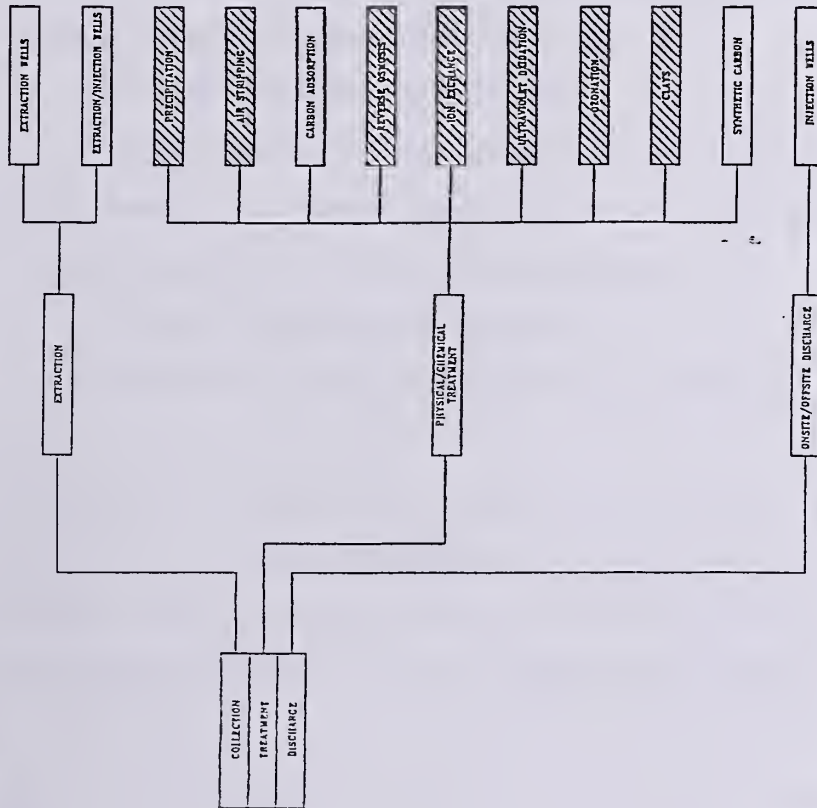
LEGEND

- TECHNOLOGIES THAT ARE SCREENED OUT.

* SCREENING EDGMENTS MAY NOT BE APPLICABLE TO ACTUAL SIZE.

[illegible]

	Jacobs Engineering Group Inc. Central Region 35-K784-03 Houston, Texas	
	CONTRACT NO. F41624-94-D-8115-0025	Dwg. No. FIGURE 3-4
Dwg. Title MMR PLUME RESPONSE PROJECT PROCESS TREATMENT FACILITY SCREENING PROCESS		SCALE NONE



LEGEND

- TECHNOLOGIES THAT ARE SCREENED OUT.

* SCREENING COMMENTS MAY NOT BE APPLICABLE TO ACTUAL SIZE.

[illegible]

CONTRACT NO. F41624-94-0-8115-0025	DWG. NO. FIGURE 3-5	REV. A	SCALE NONE
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4.0 DESCRIPTION AND LAYOUT FOR KEY SYSTEM COMPONENTS

4.1. TREATMENT SYSTEM DESIGN DETAILS

This section provides more details on the sizing of the individual items in the treatment train. Refer to Section 3.1 for a description of the SD-5 process, and Volume II for copies of the Process Flow Diagram (PFD) and the Process and Instrument Diagrams (P&ID). Overall, the treatment capacity of the system is as follows:

- Average expected flow = 355 gpm (per the OpTech groundwater modeling)
- Design flow = 450 gpm (a 20% safety factor over the OpTech modeling)
- Maximum flow = 560 gpm (an additional 25% over the design flow)
- Maximum instantaneous flow = 1000 gpm (120% over the design flow) with both feed pumps and all three Greensand filters operating, and both carbon trains operating. The flow rate would be decreased temporarily for maintenance activities or any time a Greensand filter is backwashed.
- The capacity of the Greensand filters is 393 gpm/filter at a maximum loading rate of 5 gpm/ft². The capacity with three filters is:
 - 1179 gpm with all three filters operating
 - 786 gpm with two filters operating (one filter in backwash mode).
- The capacity of the carbon filters is 350 gpm/train (average) and 525 gpm (maximum). The capacity with two parallel trains is:
 - 1050 gpm with both trains in operation
 - 525 gpm with one train operating (one train out for carbon replacement).

In addition to the built-in extra capacity, space is available in the treatment building for the installation of additional treatment equipment that will provide an additional increase in capacity to 1640 gpm, which is 260% more than the flow rate modeled by OpTech. Part of the available space is initially to be used for

maintenance activities. These activities would need to be relocated if the treatment system is expanded.

The sizing basis for the extraction and reinjection wells is described in Section 5.0, Rationale and Description for Extraction and Reinjection Systems. The sizing basis for the individual equipment in the treatment system is described in the following paragraphs.

4.1.1 Influent Holding Tank (1T-101)

The influent holding tank is designed for a five minute holdup of the incoming design flow of 450 gpm, plus backflush from the Greensand filters or the sand filters. The backflush volume provided is 1140 gpm for 10 to 15 minutes (17,000 gallons). The total volume provided is 23,000 gpm.

pH control is provided at the influent tank. The incoming pH is expected to be between 5.3 and 6.5, with the average expected to be below 6. pH adjustment to the 6.5 to 8.5 range may be required for iron and manganese removal. Therefore, the pH control system has been designed to control the pH between 6.5 and 8.5. The groundwater is only lightly buffered, so a feed-forward system is used to smooth out pH variations. The influent tank is agitated using a recirculating loop with the pH measured in the tank as a fine adjustment to the feed-forward loop. Caustic is added to the system from a storage tank using metering pumps. The caustic addition rate is expected to be about 14 gallons/day, so the 4500 gallon caustic tank will hold about an 11 month supply. The storage tank is sized to hold the contents of a 4000 gallon caustic truck.

4.1.2 Greensand Filter System

Potassium permanganate is used to convert the iron and manganese from soluble to insoluble forms. The permanganate oxidizes the metals to precipitate them from solution. The Greensand filters provide the following functions:



- The Greensand holds permanganate on its surface to protect against over feeding or underfeeding of the permanganate. If excess permanganate is added, the Greensand removes the excess from the water. If too little permanganate is added, the permanganate absorbed on the Greensand oxidizes any excess iron and manganese.
- The Greensand works as a filter to remove any suspended solids (TSS) from the influent, and to filter out the precipitated metals.

The Greensand filters were not piloted because they represent a common technology that has been proven in hundreds of applications around the country. The Greensand filters for this application were sized based on the following criteria:

- A maximum flow rate per filter of 5 gpm/ft². The maximum capacity is 393 gpm/filter for a total of:
 - 1179 gpm with all three filters operating
 - 786 gpm with two beds operating (one filter in backwash mode).
- A maximum backwash frequency of once/day per filter, or a maximum of one filter being backwashed each shift.

The RFP issued to obtain filter bids lists the above items as a duty specification.

The potassium permanganate will be received, as crystals, in 25 kg bags and will be dissolved in water prior to use. The estimated addition rate of potassium permanganate is 0.13 lbs/hr, so a 25 kg bag will last almost eight days. The mixing tank is sized to hold two batches as insurance against running out of permanganate.

4.1.3 Greensand Filter Backwash System

The backwash system is designed to handle one backwash every eight hours at a rate of 1140 gpm for 10 to 15 minutes. The system is also designed to hold up to



The components of the control systems are shown on the PFDs and P&IDs, contained in Volume II. The following is a summary of the major control features:

- The pumping rate from each of the extraction wells is on flow control. This is one of the most important control variables. Monitoring wells will be used to measure the groundwater levels and the concentrations of contaminants in the plume to insure that the extraction rates are meeting the plume containment goals. The flow rate from each well will be adjusted to achieve the containment goals.
- The flow rate from the influent tank (1T-101) through the individual Greensand filters is also on flow control. The pressure drop through each of the Greensand filters will vary significantly, depending on the time since the last backwash, so the flow control is needed to balance the flow between the filters.
- The level in 1T-101 will be allowed to vary. This capability is needed to allow the volume to vary depending on the backwash cycle.
- A high level alarm is provided on 1T-101 to warn the operator that the flow rates need to be rebalanced. If the level in the tank continues to rise, a second high level alarm will shut off the flow from the extraction wells.
- The pH of the water in the influent tank is controlled to optimize the removal of iron and manganese. The pH of the incoming water is expected to be below 6.0, and will be adjusted to 6.5 to 8.5, if required, to improve the metals removal. The pH is adjusted by adding caustic to the tank, using a recirculating loop to mix the tank.
- Potassium permanganate is added as a ratio of the flow to the Greensand filters. The ratio will be adjusted to match changes in the iron and manganese concentrations.

- The controls automatically backwash the Greensand filters when the pressure drop across a filter reaches 10 psi. The backwash rate is on flow control to maintain a backwash loading of 12 gpm/ft².
- The backwash from the Greensand filters is allowed to settle in the sedimentation tank (1T-103). After three hours of settling, the recirculating pump automatically starts and pumps the decanted water back to 1T-101.
- The removal of the sludge from 1T-103 will be manually performed. When the cone bottom of the tank is full, a truck will be called-in to haul the sludge to disposal.
- Operation of the carbon filters is on manual control. Manual valves will be used to balance the flow rate between the carbon trains, the suspended solids have been removed upstream in the Greensand filters so plugging is not expected to be a problem and the manual flow adjustments are expected to be infrequent. High differential pressure alarms will warn the operator if a carbon bed is being plugged. Samples will be collected and analyzed from between the first and second bed in each train to monitor when the carbon in the first bed is becoming exhausted. When toxic organic compounds are detected in the outlet from the first bed, the carbon in that bed will be replaced and the order of the beds will be swapped. The bed with the fresh carbon will move to the second position. During the period when the carbon is being replaced, the entire train with the replacement will be isolated from the flow to insure that the flow never passes through just one carbon bed in series. During this period, the flow rate will increase through the other train to handle the total flow.
- The effluent holding tank (1T-102) is sized to provide a five minute holdup on the flow rate to the reinjection wells plus 17,000 gallons of water to be used as backwash. The flow rate into the tank is set by the flow control valves at the Greensand filters. The flow out of the tank is set by the flow control valves at the individual reinjection wells. A level indicator allows the operator to

monitor the level in the tank. Level alarms warn the operator that action may be required to rebalance the flow rates. A second high level alarm shuts off the influent pumps before the tank would overflow.

- The addition of hydrogen peroxide, to replace the dissolved oxygen in the reinjected water, is ratioed to the reinjection water flow rate to maintain a dissolved oxygen concentration of 8 ppm.
- The flow rate to each reinjection well is on flow control, which can be adjusted remotely from the SD-5 control room. The level in the well is monitored in addition to the pressure of the reinjection water. The level and pressure both provide an indication of any fouling that will restrict flow into the well. The flow rate to each reinjection well will be adjusted periodically based on feedback from the levels in the monitoring wells, to insure that the reinjection aids the goal of capturing the plume without significantly impacting the groundwater levels in the area.

4.3 TREATMENT SYSTEM CONTAINMENT

The concentration of contaminants in the groundwater are significantly below the hazardous waste trigger levels, per the TCLP. However, as insurance against spills or leaks returning contaminated groundwater to the aquifer, containment has been provided both for the influent line from the extraction wells and for the treatment system.

Double walled piping will be used to contain any leaks in the underground piping between the extraction wells and the treatment system (see Section 4.0 for a more detailed description).

The treatment area has been designed with full spill containment and secondary containment, to contain any spills or leaks from the system. The following containment features have been provided in the design:



- The entire treatment system is installed on a concrete pad that is sloped toward collection trenches and a collection sump. The pad has a one-inch lip around the edge to direct any spills toward the trenches and the sump. The entire containment volume is:

Sloped concrete pad	11,313 gallons
Trenches	11,512
Sump	<u>942</u>
TOTAL	23,767 gallons (vs largest tank volume of 23,000 gallons)

- Water stops will be installed in all the joints in the concrete to seal the joints.
- The tanks and treatment equipment are all elevated or installed on concrete foundations that will allow the visible detection of leaks and will contain any leaks so that the leak does not reach the groundwater.
- A high level alarm is installed in the sump to warn the operator that a leak or spill has occurred. If the level in the sump continues to rise, a high-high alarm will sound and will shut off the flow from the extraction wells.

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5.0 EXTRACTION AND REINJECTION SYSTEMS

5.1 EXTRACTION WELL DETAILS

The locations, depths, screening depths, and pumping rates for the SD-5 extraction wells are based on Scenario 6, Version 10 of OpTech's SD-5 modeling report.

To be conservative and to allow for possible future expansions in pumping rates, the following allowances have been made in the design of the extraction system:

- Monitoring wells will be installed in the ETR areas that will allow evaluation of the effectiveness of the plume capture. Information from this monitoring of the water levels and contaminant concentrations in these wells will be used to insure that system operation is meeting the plume containment goals.
- The design flow rate includes a 20% safety factor over the modeled flow rate from each individual well.
- The extraction pumps have been sized for a plume drawdown of 20 feet versus a drawdown predicted by modeling of less than one foot.
- The main piping header is designed to initially operate with low flows from the wells allowing for future expansion in pumping rates and/or additional wells.
- Control valves have been provided that utilize 20% of the total system pressure drop. If these control valves are allowed to operate full open, the flow rate from each individual well can be increased by 30%.
- Isolation valves and blind flanges on the end of the headers are being installed in the extraction well header to allow the future installation of additional wells without taking the full system out of service.
- The well casings have a large enough diameter that larger pumps can be installed in the future, if needed, to significantly increase the flow from any of

the wells. The electrical supply to each well is large enough that the capacity of any individual pump can be more than doubled in the future.

The following controls are provided at each of the extraction wells:

- The flow rate from each well is automatically controlled by flow control valves. This flow will be adjusted, based on information obtained from the monitoring wells to insure that the plume containment goals are being achieved.
- The water level in each well is indicated in the control room to allow the operator to monitor the level in the plume and/or as an indication of plugging of the well screens.
- A low level cutoff is provided to protect the pump against excessive drawdown.

An air/vacuum release valve is provided that will allow the piping to drain during a shutdown and will allow the release of air during startup.

5.2 EXTRACTION PIPING CONTAINMENT

Full secondary containment is provided for both the piping inside the well vaults and for the underground piping between the vaults and the treatment system. Leak detection is provided immediately to warn the operator that a leak or spill has occurred. This is done through remote monitoring of the line. This information combined with the flow rate information available to the operator, will allow the operator to take immediate action, if required, to minimize the impact of any spill.

Containment inside the vaults is provided by the floor of the vaults. High level alarms are provided in the vaults to warn the operator of any leaks or spills.

Double-walled piping is used for the underground extracted water lines. The inner pipe contains the extracted water and the outer pipe will contain any leaks in the inner pipe. A continuous tape will be installed between the inner and outer pipes to detect any leaks. This leak detection tape has the following characteristics:

- If a leak occurs, the tape will detect the leak and will sound an alarm that will immediately warn the operator.
- The leak detection logic system will then record the exact location of the leak to minimize the excavation required to find and correct the leak.

The combination of the leak detection system with the influent flow meters will also allow the operator to take action in the unlikely event of a rupture of both the inner and outer pipes. The leak detection tape will warn the operator that a leak has occurred. The operator will then check the meter that indicates the flow rate into the treatment system. If the flow rate has dropped significantly, the operator will know that a major failure has occurred and can shut off the flow from the wells.

5.3 REINJECTION WELL DETAILS

The design basis location, depths, screen depths, and flow rates for the reinjection wells are based on Scenario 6, Version 10 of OpTech's groundwater modeling with a 20% safety factor added to the flow rates. However, the flow rate into any individual well is limited only by potential plugging in the sand pack around the well and the head pressure exerted by the pumps.

Using the design basis of allowing a maximum 0.1 foot/second velocity through the well screens, the eight-inch reinjection well screens, 60 feet long, would have a capacity to handle a reinjection rate of 5600 gpm. This is far in excess of the 10 to 70 gpm needed. This calculation is supported by short-term reinjection tests

which demonstrated, that without plugging, the water will gravity flow back into the wells.

However, some degree of plugging will occur in the reinjection wells, so the following provisions have been made to offset the plugging impact:

- The reinjection wells have been specified to be the same diameter as the extraction wells (8 inches).
- The effluent pumps, at the treatment system, have been designed to provide a minimum of 25 psig pressure at each well in case pressure is required to force the water into the groundwater formation.
- Hypochlorite injection facilities have been provided at the treatment system to allow the continuous or periodic addition of chlorine to reduce biological activity.

In addition to the above provisions provided to minimize the plugging impact, additional provisions have been made to provide flexibility into the reinjection system:

- The reinjection well header is designed to operate at low flows allowing for future expansion in flow rates or additional wells.
- Control valves have been provided that utilize 20% of the system pressure drop. If the control valves are allowed to operate wide open, the flow rate to all the wells can be increased by 25%.
- Isolation valves have been provided in the reinjection well header, plus blind flanges have been provided at strategic points on the header, to allow the future installation of additional wells without taking the entire header out of service.

The following controls are provided at each of the reinjection wells:

- The flow rate into each reinjection well is automatically controlled. This flow rate can be adjusted from the control room, based on information obtained from the monitoring wells, to insure that the reinjection wells are accomplishing their goals of balancing the groundwater levels.
- The pressure and level in each of the wells will be continuously indicated in the control room. These signals will provide the operator information on any plugging in each well.

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6.0 OPERATIONAL PHILOSOPHY AND SAFEGUARDS

6.1 PERFORMANCE MONITORING NETWORK

The purpose of the Performance Monitoring Evaluation (PME) system are to:

- Determine if the extraction, treatment, reinjection (ETR) system is meeting performance criteria, specifically including both the hydraulic capture and chemical remediation of the SD-5 plume located north of Snake Pond.
- Coordinate ETR performance monitoring with concurrent monitoring being conducted as part of the ecological monitoring program, the sitewide inorganic investigation, and the ETR System Design Operations and Maintenance (O&M) Plan.
- Collect time-series data using the observational approach, as appropriate, to optimize plume capture.

The PME is based on known aquifer characteristics, the 3-D groundwater model, and professional judgment. It will include horizontal and vertical monitoring of the contaminant plume and groundwater hydraulics system, treatment system monitoring, and compliance monitoring. A detailed PME Plan will be provided as part of the Final Design Package.

6.2 OPERATIONS AND MAINTENANCE

6.2.1 Manning Basis/Frequency

The control room at the SD-5 treatment system will normally be manned.

6.2.2 Sampling Program

The plant will meet the effluent discharge limits listed in Table 2-5 for injection. The procedures for collecting samples and the methods for sampling will be in



accordance with the HQ AFCEE QAPP. The numbers and frequency of sample collection will be included in the Final Design Package.

All samples will be grab samples, composited for analysis unless otherwise specified. All other extraction and treatment samples will be grab samples.

6.2.3 Raw Material Receipt

Chemicals will be used for a variety of purposes in water treatment. These are oxidation, disinfection, organic removal, and pH adjustment.

Chemicals used at water treatment plants will meet the applicable standards of the AWWA. The AWWA publication number for these standards are:

Category	AWWA Standard	Chemical Name
Hypochlorite	B-300	Sodium hypochlorite (hypochlorites)
pH	B-501	Caustic soda
Oxidant	B-603	Potassium permanganate
Organics	B-604	Granular activated carbon

The selection of methods of chemical handling and storage were based primarily on ease of operation, operating flexibility, and safety considerations. Chemicals will be received in shipping containers such as bags, boxes, drums, or canisters. Equipment used for chemical handling will include carts, dollies, fork lifts, etc. If chemicals are shipped in bulk quantities, the mode of unloading depends on the physical characteristics of the chemical. Bulk liquids, such as caustic, will be unloaded by pumping from the truck to the tank at the treatment plant. Chemicals shipped in bags, drums, barrels, or other shipping containers will be stored by placing these containers in a specific storage area. Hazardous chemicals will be stored in separate rooms to avoid reaction of chemical vapors.

Chemical solutions will be applied directly, or after dilution, to the water being treated by volumetric liquid feeders such as metering pumps. Rapid, thorough mixing of the chemical solution will be provided.

6.2.4 Greensand Treatment

The manganese Greensand treatment system will be regenerated with potassium permanganate (KMnO_4) on a continuous basis. The system will operate as a standard pressure filter system. The KMnO_4 , without chlorine, can be estimated as follows:

$$\begin{aligned}\text{mg/l KMnO}_4 &= (1 \times \text{mg/l Fe}) + (2 \times \text{mg/l Mn}) \\ &= 1 \times 0.243 + 2 \times 0.044 \\ &= 0.243 + 0.088 \\ &= 0.331 \text{ mg/l}\end{aligned}$$

The backwash flow rate will be sufficient to produce a 35% bed expansion. The normal flow rate will be 1140 gpm for a 12 ft. diameter vessel or 12 gpm/ft.².

The Greensand treatment will be backwashed when the pressure drop reaches 10 psi. After each service cycle the manganese Greensand will be backwashed for 10 - 15 minutes to remove suspended material collected during the service. The manganese Greensand will be expanded a minimum of 35% during backwash.

6.2.5 Carbon Adsorber Installation And Start-Up

The carbon adsorbers will be installed in accordance with the written instructions of the manufacturer. Also, the work will be done with the recommendations of the manufacturer's representative.

Media will be loaded by carbon slurry. The activated carbon will be transferred between vessels at a rate recommended by the manufacturer. Services will be provided by a representative of the manufacturer who is experienced in the

installation, adjustment, and operation of the equipment. The representative will observe and recommend the installing, adjusting, and testing of equipment.

The manufacturer will conduct training. The training will be for designated operating, maintenance and support staff members. The training period will be during normal working time. The training will start after the adsorbers are functionally complete but prior to final acceptance tests. Field training will cover all of the items contained in the operating and maintenance instructions.

All products will be carefully inspected for defects in workmanship and material. Debris and foreign matter will be cleaned out of valve openings and seats. All operating mechanisms will be operated to check the proper functioning. All fasteners, nuts and bolts will be checked for tightness. Valves and other equipment that does not operate easily or are otherwise defective will be repaired or replaced.

After installation of the activated carbon adsorption system, operating tests will be conducted. These will assure that the system operates properly. Any deficiencies revealed during the tests, will be corrected.

Operating Instructions

The adsorption system is a unit consisting of four (4) vertical pressure vessels, operating as two (2) parallel pairs of two (2) vessels in series. Each vessel contains 20,000 pounds of granular activated carbon (total of 40,000 pounds per system). The vessels are complete with underdrain. Face piping and carbon transfer piping is shipped loose for installation in the field. The adsorber vessels are free-standing vessels, with the central piping assembly preassembled.



After connecting the influent and effluent piping to the system, the vessels can be operated in a series or parallel configuration. Granular activated carbon will be delivered to the site in bulk trailers for unloading directly as a water slurry into an empty adsorber.

Extracted groundwater will be pumped to the adsorption system at a flow rate compatible with the design capacity of the unit.

Flow is directed into the top of the first vessel in each set (lead adsorber) and flows down through the carbon. From the bottom of the lead adsorber, the stream flows into the top of the second adsorber (backup adsorber).

When the carbon in a vessel is exhausted, an empty trailer is sent to the site to remove the load of spent carbon. The carbon will be returned to a vendor for thermal reactivation.

The spent carbon is transferred from the adsorber to the bulk trailer by first filling the adsorber with water. The adsorber is then pressurized using compressed air as the motive force to facilitate the carbon transfer to the trailer.

Once the spent carbon transfer operation is completed, a charge of fresh carbon can be transferred into the empty adsorber. This is accomplished by filling the bulk trailer with water and using a water cushion in the adsorber. The bulk trailer is then pressurized with compressed air to facilitate the carbon transfer into the adsorber.

In parallel operation, when one set of vessels is taken out of service, flow is directed to the remaining train for uninterrupted operation. After the first set is emptied and then filled with fresh carbon, it can be placed on-stream.



Differential pressure switches are supplied to measure the pressure drop across each bed. Pressure drop through an adsorber system is a function of many factors:

- Pressure drop through the carbon bed(s).
- Nozzle and piping pressure drop.
- Mode of operation (series or parallel).
- Flow rate, viscosity, and density of the liquid.
- Solids build-up on top of the bed.
- Bacteria growth or chemical precipitation in the bed.
- Gas build-up in the bed.

Backwashing/backflushing is usually required when the pressure drop across an adsorber increases by 5 to 10 psi during the adsorption cycle.

Standard units come equipped with a 45° internal cone. This internal cone offers many advantages, such as ease of carbon removal and good flow distribution through the nozzle underdrain. Since the internal cone is not part of the exterior vessel, it is designed to withstand a working differential pressure of 20 psi. Note that this differential pressure is less than the maximum allowable working pressure (MAWP) for the vessel. High cone pressure differential could exist due to:

- Unlimited backwash water flows. This is probably the most dangerous situation since the cone is weaker in the upflow direction.
- Nozzle pluggage due to precipitation, fines, or bacteria. This could happen either in the backwash or process operation.
- Unlimited process flow.

Do not operate the system unless the differential pressure switches on each vessel are operating properly. A high differential pressure that could cause damage to the internal cone could go undetected.

To prevent damage to the system in the event that the pressure limitation of the vessels is exceeded, pressure relief devices are provided in the adsorber vent lines.

After startup, records will be kept of pertinent data such as flow rate, pressure drop across each bed, total dissolved solids, temperature, pH and specific organic constituents.

6.2.6 Sludge Removal

Sludge will be removed from the sedimentation tank (IT-103). The sludge will be 30 pounds per 15,000 - 17,000 gallons of backwash water from the Greensand filter. There will be two (2) backwashes per day. This results in 30,000 - 34,000 gallons per day and 60 pounds of solids.

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